CS519: Computer Networks

Lecture 1 (part 2): Jan 28, 2004
Intro to Computer Networking

Remember this picture?

- How did the switch know to forward some packets to B and some to D?

From the address in the packet header...

- A packet has a header and a body
  - and, sometimes, a trailer
- The header says:
  - Where the packet is going (address)
  - How big the packet is (length)
  - Some other stuff

Packets

... Body Header Body Header

Tells where the next packet is

Length Address

Tells where to route the packet
Like an envelope?

- The address field is somewhat analogous to the address on an envelope
  - And the contents of the envelope would then be like the packet body
- But this analogy doesn’t work for the length field!

Forwarding Table

- Routers (or switches) have a forwarding table
  - Router is a forwarding box that operates on IP packets
- This table is indexed by the address in the header, and tells which next hop to send the packet to
- Addresses can be hierarchical (like phone numbers)

Forwarding tables and routing algorithms

- How did the forwarding table get there?
  - Typically a routing algorithm is run among the routers, and this algorithm establishes the contents of the forwarding table
- In this class, we’ll look in detail at address structures and routing algorithms
Two kinds of links

- Routers and hosts in the Internet are typically connected by two types of links
- We’ve been looking at pictures of point-to-point links
- The other common kind is the broadcast link
  - Usually Ethernet

Point-to-point and broadcast links

- Point-to-point
- Broadcast
Broadcast link (Ethernet)

- Well, N packets are “seen”, not really received
- The Ethernet hardware filters out packets that are not for “self”
  - By examining the Ethernet address
- The operating system (OS) never sees the packet (no packet interrupt)
- Though Ethernet does have multicast and broadcast address

Ethernet addresses and IP addresses???

- As you all know, the Internet is a network of networks
  - That's why it's called the Internet
- This introduces the concepts of:
  - Interface
  - Encapsulation

Next hop and interface (and logical interface!)

- Next hop is the next router on the path to the destination host
  - Or may be the destination host itself
- Interface is the input/output port over which the next hop can be reached
  - May be physical (an actual wire)
  - Or logical (multiple interfaces on an actual wire)
So the router has another table (neighbor table)

Router packet forwarding procedure:

- Look up dest IP address in received packet
- Obtain Next Hop router (its IP address)
- Look up Next Hop router in the Neighbor Table
  - (with a pointer from the forwarding table entry)
  - Obtain iface (interface) and “link” address of Next Hop router
- Encapsulate IP packet in link packet and send over iface
Packets (revisited)

But, what is “where”?

- To an Ethernet, “where” is an Ethernet port
  - Ethernet address
- To the Internet, “where” is a host computer on a network
  - IP address
- To a host computer, “where” is a process
  - TCP or UDP port
- To a process, “where” may be a file
  - HTTP URL

A stack of headers

A stacked header requires one more field: “next header”
Except for the physical layer protocol, protocol peers communicate with each other by talking to a lower layer.
- HTTP peers use TCP, TCP peers use IP, etc.
- We say that each protocol provides a service to the layer above it.
- Often there is a service interface that defines the service.
**Example Microsoft VPN stack**

<table>
<thead>
<tr>
<th>Application</th>
<th>TCP</th>
<th>IP</th>
<th>PPP</th>
<th>L2TP</th>
<th>UDP</th>
<th>IPsec</th>
<th>IP</th>
<th>ppp</th>
<th>PPPoE</th>
<th>Ethernet</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

- The actual end-to-end network and transport layers
- A network abstraction that Microsoft finds convenient
- A security layer
- A tunnel
- A logical link layer
- The link layer

**TCP:** Transport Control Protocol
**IP:** Internet Protocol
**PPP:** Point-to-Point Protocol
**L2TP:** Layer 2 Tunneling Protocol
**UDP:** User Datagram Protocol
**IPsec:** Secure IP
**PPPoE:** PPP over Ethernet

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**Protocol layers revisited**

- TCP addressing gets packets across this boundary
- OS boundary

- Network Interface
- Hardware boundary

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**Summary of lecture 1**

- *Packet networks* are more flexible than *circuit networks*
- But have "QoS" issues of *delay* (latency), *dropping*, and *jitter* (versus *blocking* for circuit networks)
- *Fancy queuing* can help, but ultimately traffic sources have to slow down to avoid *congestion*
Summary of lecture 1

- Delay has three components, queuing, propagation, and transmit
- Large Delay x Bandwidth Product pipes are becoming more common
- Packets have headers that tell where the packet is going, and how long it is (among other things)

Routers have forwarding tables that select the next hop in a path to an address
- And neighbor tables that tell which interface and link address to use to get to the next hop
- Encapsulation is used to get the IP packet from one router to another over a link

Summary of lecture 1

- Protocols are layered, with each layer providing a communications service to the layer above
- The layering is complex, with tunnels that allow protocols to be layered over themselves
- IP is a special layer at the waist of the Internet hourglass.

Next Lecture: IP

- Because of IP’s special position in the Internet, it seems reasonable to start with IP, then work down and up…