A Very Brief Introduction to Networking

Simplest Network
Local Area Network (LAN)

Network of LANs

Internetworking
- Internetwork = Collection of networks connected via routers
Internet = Virtual Network

Sending a packet from Argon to Neon

DNS: What is the IP address of "neon.tcpip-lab.edu"?
ARP: What is the MAC address of 128.143.71.21?

DNS: The IP address of "neon.tcpip.edu" is 128.143.71.21

Sending a packet from Argon to Neon

Sending a packet from Argon to Neon

Sending a packet from Argon to Neon

ARP: What is the MAC address of 128.143.137.17?
ARP: The MAC address of 128.143.137.1 is 00:e0:fa:23:a8:20

Sending a packet from Argon to Neon

128.143.71.21 is on my local network. Therefore, I can send the packet directly.
Sending a packet from Argon to Neon

ARP: What is the MAC address of 128.143.71.211?

ARP: The MAC address of 128.143.71.1 is 00:20:af:03:98:28

Sending a packet from Argon to Neon

Sending a packet from Argon to Neon

Sending a packet from Argon to Neon
Communications Architecture

- The complexity of the communication task is reduced by using multiple protocol layers:
  - Each protocol is implemented independently
  - Each protocol is responsible for a specific subtask
  - Protocols are grouped in a hierarchy
- A structured set of protocols is called a communications architecture or protocol suite

TCP/IP Protocol Suite

- The TCP/IP protocol suite is the protocol architecture of the Internet
- The TCP/IP suite has four layers: Application, Transport, Network, and Data Link Layer
- End systems (hosts) implement all four layers. Gateways (Routers) only have the bottom two layers.

OSI and TCP/IP Protocol Stack
Functions of the Layers

- **Data Link Layer:**
  - **Service:** Reliable transfer of frames over a link
  - **Media Access Control on a LAN**
  - **Functions:** Framing, media access control, error checking

- **Network Layer:**
  - **Service:** Move packets from source host to destination host
  - **Routing, addressing**

- **Transport Layer:**
  - **Service:** Delivery of data between hosts
  - **Connection establishment/termination, error control, flow control**

- **Application Layer:**
  - **Service:** Application specific (delivery of email, retrieval of documents, reliable transfer of file)
  - **Functions:** Application specific

Assignment of Protocols to Layers

Layered Communications

- An entity of a particular layer can only communicate with:
  1. a **peer layer entity** using a common protocol
Exchange of Data

- The unit of data sent between peer entities is called a Protocol Data Unit (PDU).
- For now, let us think of a PDU as a single packet.

**Scenario:** Layer-N at A sends a layer-N PDU to layer-N at B.
- What actually happens:
  - A's layer-N passes the PDU to the SAPs at layer-N-1.
  - Layer-N-1 entity at A constructs its own (layer-N-1) PDU which it sends to the layer-N-1 entity at B.
  - PDU at layer-N-1 = layer-N-1 Header + layer-N PDU.

Layers in the Example

**Layers in the Example**

HTTP
TCP
IP
Ethernet
argon.tcpip-lab.edu 128.143.137.144
router71.tcpip-lab.edu 128.143.137.1 00:e0:79:23:a8:20
router137.tcpip-lab.edu 128.143.71.1
neon.tcpip-lab.edu 128.143.71.21

Send HTTP Request to neon
Establish a connection to 128.143.71.21 at port 80

Open TCP connection to 128.143.71.21 port 80

Send a datagram (which contains a connection request) to 128.143.71.21
Layers in the Example

HTTP
  └── TCP
    └── IP
      └── Ethernet

     argon.tcpip-lab.edu
     128.143.137.144

     router71.tcpip-lab.edu
     128.143.137.1
     00e6f923a820

     router137.tcpip-lab.edu
     128.143.71.7

     neon.tcpip-lab.edu
     128.143.71.21

Encapsulation

- As data is moving down the protocol stack, each protocol is adding layer-specific control information.
Ethernet

- Computer <> Computer communication on same network
- Each device has unique MAC address (48-bit)
  example: 00-C0-4F-48-47-93

Ethernet Packet:

<table>
<thead>
<tr>
<th>Preamble</th>
<th>Dest. address</th>
<th>Source address</th>
<th>Type</th>
<th>Data</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>8bytes</td>
<td>6bytes</td>
<td>6bytes</td>
<td>2bytes</td>
<td>64 - 1500bytes</td>
<td>4bytes</td>
</tr>
</tbody>
</table>

MAC: Media Access Control

IP: Internet Protocol

- Unreliable ... connectionless datagram delivery service
- Responsible for routing of data through intermediate networks and computers

IP header:

<table>
<thead>
<tr>
<th>Version</th>
<th>IHL</th>
<th>Type of Protocol</th>
<th>Total Length</th>
<th>Identification</th>
<th>Flags</th>
<th>Fragment Offset</th>
<th>Protocol</th>
<th>Header Length</th>
<th>DataOffset</th>
<th>Data</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>17</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IP: Internet Protocol

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Type</th>
<th>Code</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

ICMP: Internet Control Message Protocol

- Used to report problems with delivery of IP Datagrams within an IP network
- Used by Ping, Traceroute commands

ICMP Message

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>11</td>
<td>0</td>
</tr>
</tbody>
</table>

Types and Codes

- Echo Request (type=8, code=0)
- Echo Reply(type=0, code=0)
- Destination Unreachable(type=3, code=0)
- Time Exceeded(type=11, code=0): Time-to-Live =0
TCP: Transmission Control Protocol
- Connection-Oriented, Reliable, Byte Stream Service Protocol
- 1. Set up connection
- 2. Transfer data
- 3. Close connection

TCP Header Format:

<table>
<thead>
<tr>
<th>Source Port</th>
<th>Destination Port</th>
<th>Sequence Number</th>
<th>Acknowledgement Number</th>
<th>Window</th>
<th>Offset</th>
<th>Data Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TCP Payload</td>
</tr>
</tbody>
</table>

ARP: Address Resolution Protocol
- ARP provides mapping
  - 32bit IP address <-> 48bit MAC address
  - 128.97.89.153 <-> 00-C0-4F-48-93
- ARP cache
  - maintains the recent mappings from IP addresses to MAC addresses

Protocol:
- 1. ARP request broadcast on Ethernet
- 2. Destination host ARP layer responds

DNS: Domain Name System
- DNS provides mapping
  - www.cs.colostate.edu <-> 129.82.45.114
  - and many other mappings
    - mail servers, IPv6, reverse mapping
- Data is organized as a tree
DNS Protocol

what is www.colostate.edu
what is www.colostate.edu
what is www.colostate.edu
what is www.colostate.edu
what is www.colostate.edu
what is www.colostate.edu
what is www.colostate.edu

Root DNS Server
.edu DNS Server
colostate.edu DNS Server
colostate.edu
.edu
.colostate.edu

129.82.103.106