From the moment you type in an http link in a web browser until you get the required webpage displayed in the browser, what has exactly happened?
Physical vs. Logical Communication

Logical communication between processes

Logical communication between end systems

Logical communication between directly connected units

Application Layer

Socket Programming
- Difference in UDP and TCP
- Socket programming
- Byte order
- What does "accept()" do?
- What does "listen()" do?
- What does "socket()" do?
- What does "connect()" do?

Transport Layer Services

Reliable data transfer
- Stop and wait
- Sliding window
- Selective repeat

Flow control
- Receiver's window vs. receiver's buffer

Congestion control
- Slow start and AIMD

Connection management
- Three-way handshaking
- Connection termination
- Message exchange detail
The Network Layer

- **Routing**
- **IP protocols**
  - **Addressing**
    - Hierarchical addressing (5 classes)
    - Classless addressing (CIDR)
    - DHCP
    - NAT
  - **Fragmentation**
  - **Error monitoring**
    - ICMP

Routing

- **Static routing**
- **Dynamic routing**
  - Centralized routing
    - Link state
    - The oscillation problem
    - Decentralized routing
    - Distance vector
    - Count to infinity problem
    - Good news vs. bad news
  - Internet routing
    - Hierarchical routing (what is AS? Why hierarchical routing?)
    - Intra-domain routing
    - OSPF, RIP
    - Inter-domain routing
    - BGP

TCP Header

```
<table>
<thead>
<tr>
<th>Field</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Port</td>
<td>0-4</td>
</tr>
<tr>
<td>Destination Port</td>
<td>5-9</td>
</tr>
<tr>
<td>Length</td>
<td>10-15</td>
</tr>
<tr>
<td>Checksum</td>
<td>16-31</td>
</tr>
<tr>
<td>Source Port</td>
<td>32-36</td>
</tr>
<tr>
<td>Destination Port</td>
<td>37-41</td>
</tr>
<tr>
<td>Sequence Number</td>
<td>42-47</td>
</tr>
<tr>
<td>Acknowledge Number</td>
<td>48-52</td>
</tr>
<tr>
<td>HLEN</td>
<td>53-55</td>
</tr>
<tr>
<td>Reserved</td>
<td>56-57</td>
</tr>
<tr>
<td>Code Bits</td>
<td>58-59</td>
</tr>
<tr>
<td>Window</td>
<td>60-63</td>
</tr>
<tr>
<td>Checksum</td>
<td>64-67</td>
</tr>
<tr>
<td>Urgent Pointer</td>
<td>68-71</td>
</tr>
<tr>
<td>Options (if any)</td>
<td>72-79</td>
</tr>
<tr>
<td>Padding</td>
<td>80-31</td>
</tr>
</tbody>
</table>
```
IP Header

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Version</td>
<td>Identifies the protocol version</td>
</tr>
<tr>
<td>IHL</td>
<td>Indicates the length of the IP header</td>
</tr>
<tr>
<td>Type of service</td>
<td>Specifies the type of service</td>
</tr>
<tr>
<td>Total length</td>
<td>Total length of the IP packet</td>
</tr>
<tr>
<td>Identification</td>
<td>Identifies the data packet</td>
</tr>
<tr>
<td>Fragment offset</td>
<td>Offset of the fragment</td>
</tr>
<tr>
<td>Time to live</td>
<td>Time left for the packet to reach its destination</td>
</tr>
<tr>
<td>Protocol</td>
<td>Protocol used for the packet</td>
</tr>
<tr>
<td>Header checksum</td>
<td>Checksum for the IP header</td>
</tr>
<tr>
<td>Source address</td>
<td>Source address of the sending host</td>
</tr>
<tr>
<td>Destination address</td>
<td>Destination address of the receiving host</td>
</tr>
<tr>
<td>Options</td>
<td>Options (1 or more words)</td>
</tr>
</tbody>
</table>

Link Layer and MAC Layer Summary

- **Link layer services**
  - Flow control
  - RDT
  - Error detection
    - CRC
  - Error correction
    - Hamming distance and Hamming code

- **Link layer addressing**
  - ARP

- **Specific link layer technologies**
  - PPP
  - Ethernet
    - Special features (CSMA/CD, encoding)
  - IEEE 802.11 LANs (CSMA/CA)

- **Multiple access protocols (MAC)**
  - ALOHA
  - Carrier sensing
    - 1-persistent
    - P-persistent
    - Non-persistent
    - CSMA/CD
  - Wireless LAN

- **Link layer switching**
  - Hubs
  - Bridges
  - Switches