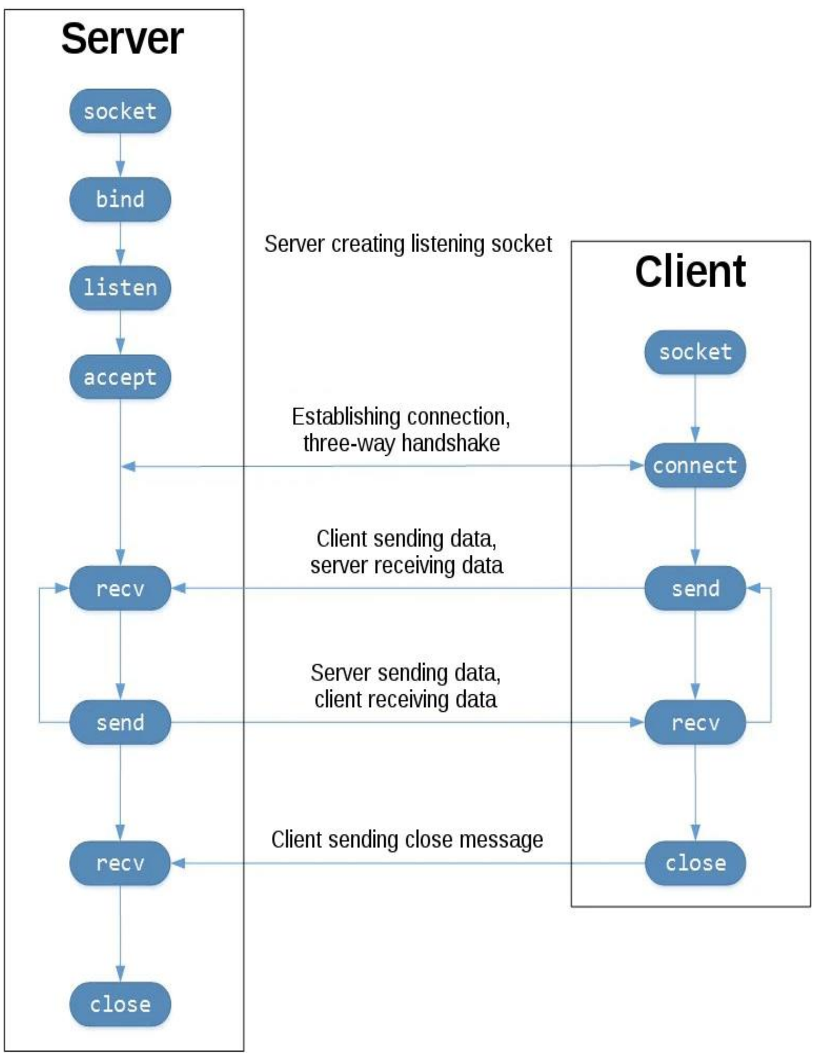
Key concepts:

1. Application Programming Interface (API) – an interface that allows two computers to communicate. You can send data from one computer to another computer via an API. From the textbook's perspective, its referring to the interface that the operating system (OS) provides to its networking subsystem.
    a. The API provides the ability to utilize the services provided by the protocol. It dictates the syntax to which the protocol can be invoked.
2. Socket – the point where a local application process attaches to the network. Actions related to a socket:
    a. Create socket
    b. Attach socket to a network (bind)
    c. Sending and receiving messages through the socket
    d. Closing the socket

A socket is the interface (link) between your application process on your computer and the network.



- Network performance is measured in two fundamental ways: bandwidth and latency.
    - Bandwidth is also known as throughput. The bandwidth of a network is given by the number of bits that can be transmitted over the network in a certain period of time.
    - For example, a bandwidth that's 10 Mbps is 10 million bits/s, so that means it can deliver 10 million bits every second.
    - Latency is also known as the delay.
    - Latency is measured strictly in terms of time. Corresponds to how long it takes a message to travel from one end of a network to the other.
- Many times, it's important to know the round trip time (RTT) of when a message goes from the source to the destination and then back to the source. This concept is known as the round trip time (RTT) of the network.
- Latency has three components:
    1. Propagation – this represents the speed of light propagation delay. This delay occurs due to the speed of light over a physical medium in relation to distance:
        a. Propagation = distance/speed of light
    2. Transmit – this is the amount of time it takes to transmit a unit of data. It's a function of the network bandwidth and the size of the packet to which the data is carried.
        a. Transmit = size/bandwidth
    3. Queue – this represents the queuing delays inside the network, e.g. since packet switches generally need to store packets for some time before forwarding them on to an outbound link.
    4. Latency = Propagation + Transmit + Queue
    5. Propagation = Distance/Speed of Light
    6. Transmit = Size/Bandwidth
- For some applications latency dominates bandwidth. For others, bandwidth dominates latency.
- Example of latency dominating bandwidth:
    - 1 byte message sent from coast to coast (e.g. Los Angels to New York and back). So that round trip time could be 100 ms.
    - 1 byte message sent across the room and back, that could be 1 ms RTT.
    - Whether the channel is 1 Mbps or 100 Mbps is not significant, since the former implies that the time to transmit a byte is 8 microseconds vs the latter's .08 microseconds.
    - Calculation assuming 10 Mbps (you can try this calculation for 1 Mbps and 100 Mbps):
        - 1x8 bits/10x10^6 bps = .8 microseconds
- Example of bandwidth dominating latency:
    - 25 MB image
    - The more bandwidth that's available, the faster it will be able to return the image to the user.
    - If the bandwidth is 10Mbps, it would take 20 s to transmit the image:
        - 25x10^6x8 bits / 10x10^6 bps = 20 s.
- Example in regards to ever increasing bandwidth in terms of fixed latency.

- 1 MB file over a 1 Mbps network versus 1 Gbps network.
- Both of which have a RTT of 100 ms.
- In the case of the 1 Mbps network, it takes 80 RTT's to transmit the file. During each RTT, 1.25% of the file is sent.
  - Calculation:
  - Find the delay x bandwidth (width of the pipe)
  - Delay is 100 ms and that's the same as .1 s
  - Bandwidth is 1 Mbps and that's 1,000,000 b/s
  - So the width of the pipe is .1 s x 1,000,000 b/s = 100,000 bits
  - So to fit 1 MB (which is 8,000,000 bits), you would have:
    - 8,000,000 bits/100,000 bits = 80 RTT's needed.
- Compare that to a 1 Gbps link using that same 1 MB file. It doesn't even come close to filling 1 RTT worth of the link.
  - Calculation:
  - Find the delay x bandwidth (width of the pipe)
  - Delay is 100 ms and that's .1 s
  - Bandwidth is 1 Gbps and that's 1,000,000,000 b/s
  - So the width of the pipe is .1 s x 1,000,000,000 b/s = 100,000,000 bits
  - So to fit 1 MB (which is 8,000,000 bits), you would have:
    - 8,000,000 b/100,000,000 b = .08 RTT's needed

- Peering allows ISP's and other networks to work together to route traffic.
- In regards to connecting two nodes, we have six main considerations:
  1. Determining the physical medium to use. E.g. fiber optics, radio waves, etc.
  2. Encoding the bits onto the transmission medium so that they can be understood by a receiving node.
  3. Delineating the sequence of bits transmitted over the link into complete messages that can be delivered to the end node. This is known as the framing problem, and the messages delivered to the end hosts are called frames (also known as packets).
  4. Frames can be corrupted at times during transmission, so it's necessary to detect these errors and take the appropriate action. This is known as the error detection problem.
  5. Making the links reliable even though the frames could be corrupted.
  6. When links are shared by multiple hosts (typically in wireless links), it's necessary to mediate access to the link. This is the media access control problem.

Section 2.1 example regarding 56 kbps:

You would need a signal to noise ratio of over 416k to achieve 56 kbps, and that corresponds to about 56 db.

Calculation:

56000 = 3000 * log2(1+S/N), now solve for S/N

56000/3000 = log2(1+S/N)

2^(56000/3000) = 1 + S/N

2^(56000/3000) – 1 = S/N

S/N = 416,126.66

Now that we have the S/N (signal to noise ratio), we can obtain the decibels:

db = 10*log(S/N) = 10*log(416126.66) = about 56 db