

CS 725/825 & IT 725

Lecture 8

Application Layer

September 30, 2026

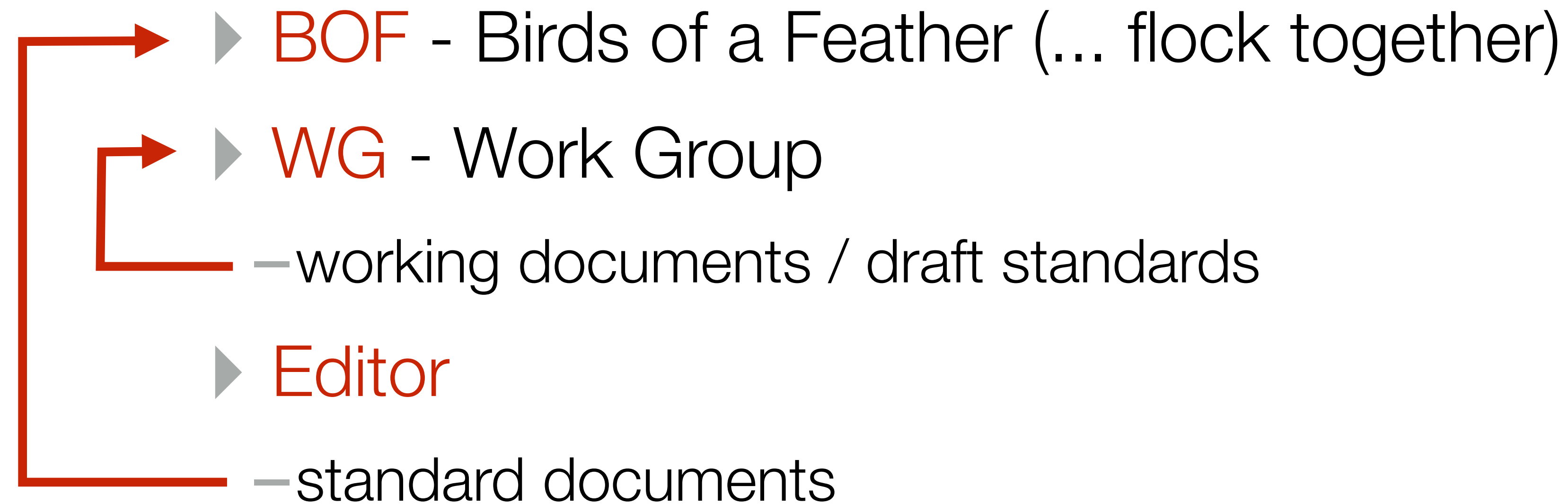
Standardization

- ▶ **ISO** - International Organization for Standardization
- ▶ **ITU-T** - International Telecommunication Union - Telecommunication Sector
- ▶ **IEEE** - Institute of Electrical and Electronic Engineers
- ▶ **IETF** - Internet Engineering Task Force
- ▶ **x Forum / x Alliance / x Group**

Standardization

- ▶ **IEEE** - Institute of Electrical and Electronic Engineers
 - 802.3an: 10GBASE-T 10 Gbit/s (1,250 MB/s) Ethernet over unshielded twisted pair (UTP)
 - 802.11ad: (in works) gigabit “WiFi” in 60 GHz band
- ▶ **IETF** - Internet Engineering Task Force
 - RFC791: Internet Protocol - DARPA Internet Program Protocol Specification (1981)

Standardization Process



Application Layer

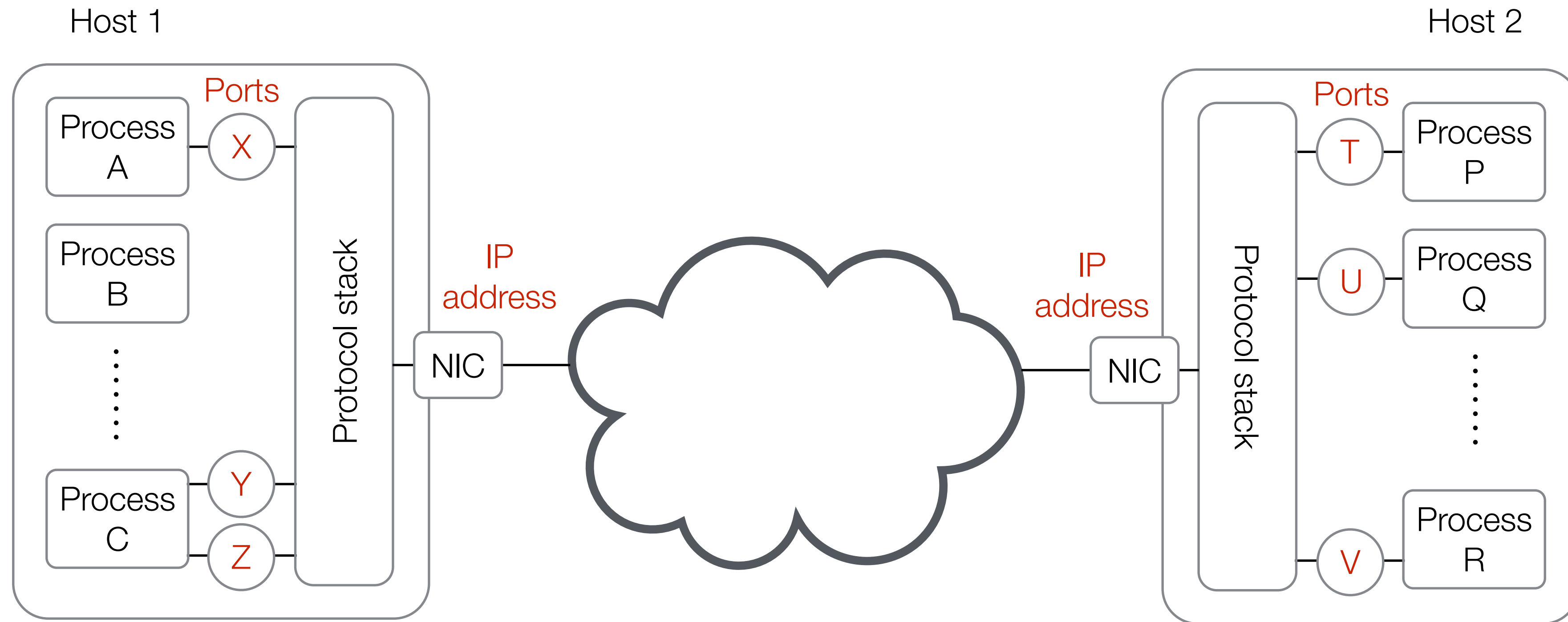
Application Layer

► Assumptions:

- each host (each network interface, actually) has a **globally unique id** (IP address)
- each communication endpoint of an application has an **id that is unique within the host** (port number)
- underlying network provides **reliable connection-oriented** or **unreliable connection-less** service (TCP or UDP)

► For a particular transport protocol, each “communication” is uniquely identified by a quadruple: *src/dst IP addresses* & *src/dst port numbers*

Client and Server



NIC - Network Interface Card

Client and Server

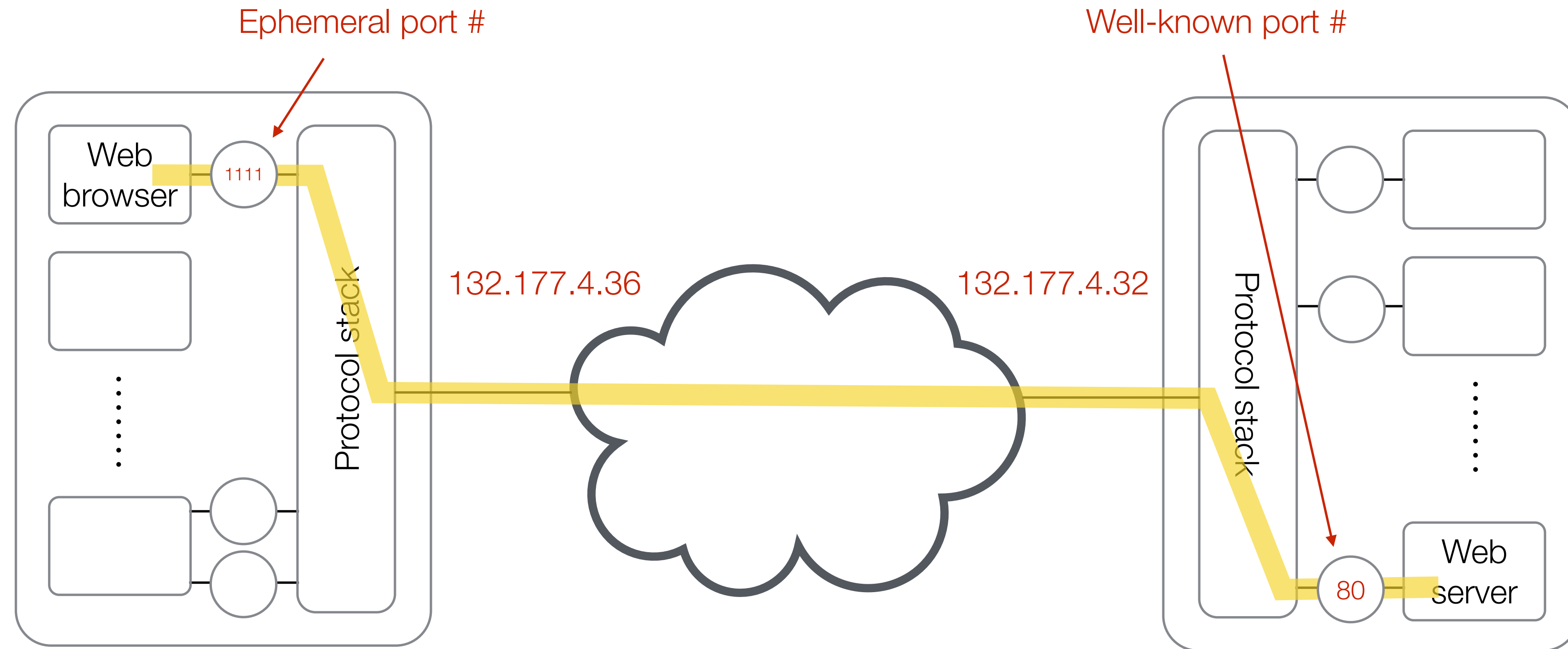
► Client (caller)

- actively opens connection to a server
- must know server's IP address and port #
- typically uses *ephemeral* source (local) port number

► Server (callee)

- connects to a local port (typically a well-known one)
- waits for clients to connect
- may handle multiple simultaneous client connections

Client and Server



A process (web browser) connected to ephemeral port **1111** on a host with IP address **132.177.4.36** opens connection to a process that listens on well-known port **80** (web server) on a host with IP address **132.177.4.32**

Socket API

- ▶ Berkeley socket API (4.2 BSD Unix, 1983)
- ▶ POSIX socket API (reentrant)
- ▶ Designed to support any protocol - not just TCP/UDP/IP
- ▶ Defined in C, but adopted by essentially all programming languages

Perspectives

- ▶ Reliable, stream-oriented service (TCP)
 - Connection-oriented client-side
 - Connection-oriented server-side
- ▶ Unreliable, datagram service (UDP)

Main Operations

- ▶ Address resolution (DNS)
- ▶ Binding to a local port number
- ▶ Client opening connection to a server
- ▶ Server accepting connections from clients
- ▶ Sending and receiving data
- ▶ Getting and setting connection parameters
- ▶ Closing connection
- ▶ Server handling of simultaneous connections

In Python...

- ▶ Address resolution (DNS)
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Server

```
import socket
BUFFER_SIZE = 100

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind(('', 54321))
s.listen(5)
ss, remote_address = s.accept()
print('Received', ss.recv(BUFFER_SIZE).decode())
ss.send('Message from agate\n'.encode())
ss.close()
```

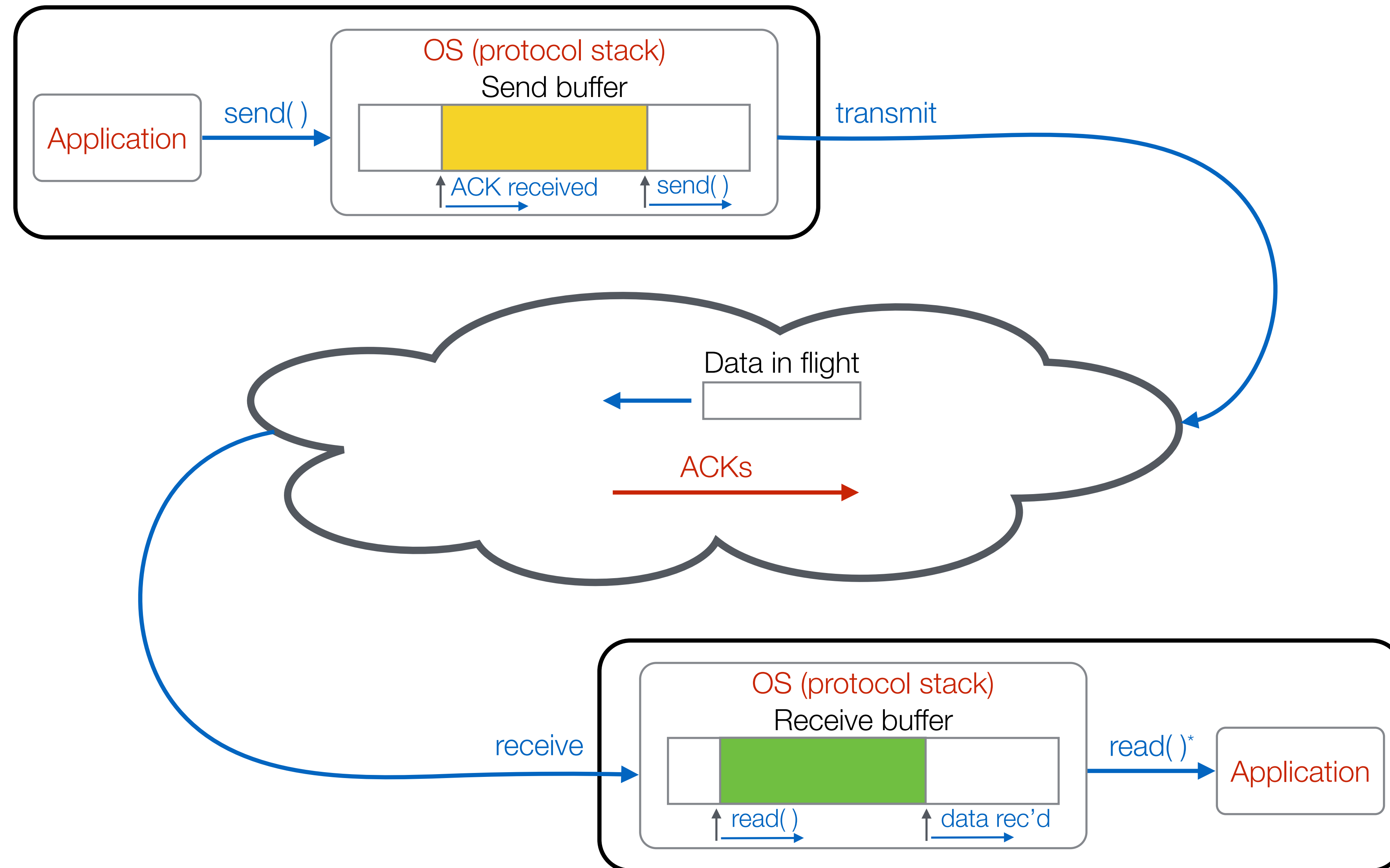
Client

```
import socket
BUFFER_SIZE = 100

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect(('agate.cs.unh.edu', 54321))
s.send('Message to agate\n'.encode())
print('Received', s.recv(BUFFER_SIZE).decode())
s.close()
```

This is in no way an example of how to write networking code! Among other issues, the code does not even do the most trivial error checking

Flow of data



(*) many APIs call the read() operation "receive" (eg: recv()), read is used here to avoid confusion with receiving data on an interface