CSE 461:
Computer Networks

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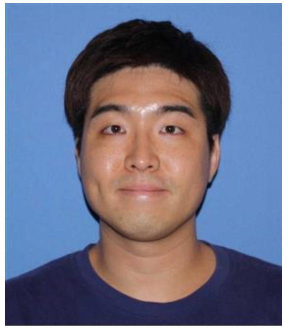


Chunjong Park

Grading

- Assignments/Projects/Homeworks: 55%
- Midterm: 15%
- Final: 30%

Reading Material:

- *Computer Networking: A Top-Down Approach*
  Kurose, Ross
  6^{th} Edition (7^{th} Edition, 5^{th} Edition, …)

- Other networking books would be fine as well

- There is a lot of information available online
  (but it’s much harder to read a paragraph here and there than a book)

Administration

- Office hours
  - Opportunity to have more persona interactions with both me and the TAs.
- Course Resources
  - Mailing list: one-way communication
  - Dropbox: Homework
  - GoPost Forum: Back and forth discussions on class content
  - Gradebook: Grades will be posted here
- Slides
  - Customized, department-communal slides

Late Policy

- There is a policy on the course web
- We understand there can be unusual circumstances…

Sections

- Start tomorrow

CSE 461: Computer Networks

Our Goals

- We'll spend most of our time studying our the Internet is built
- The Internet consists of hardware and software
  - NIC, switches, routers, hosts, WiFi, Ethernet, …
  - DNS, TCP, IP, BGP, etc.
- The Internet is an implementation of a (many) distributed algorithm(s)
  - So are distributed applications

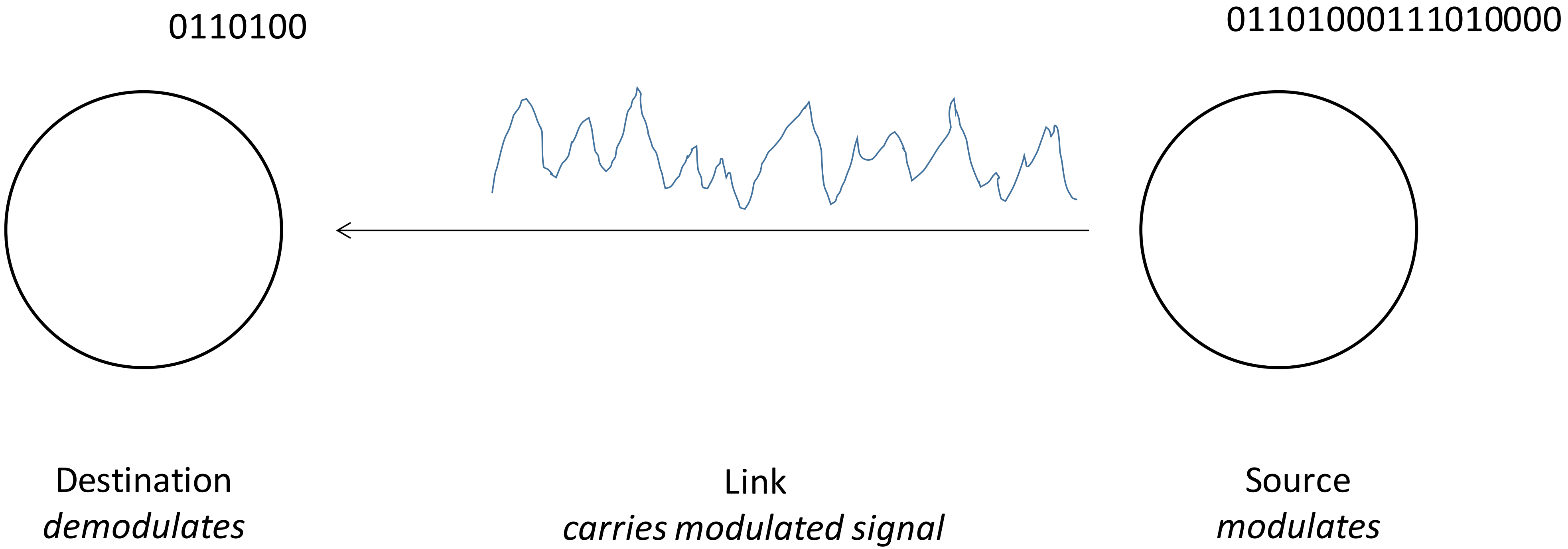
Our Goals (cont.)

- The Internet must confront a number of problems inherent in distributed systems
  - The major complication is that each agent can observe only its own state
  - It must infer the state of other agents based on what it knows about how they act
    - What protocol they run
  - The possibility of errors adds a significant level of difficulty

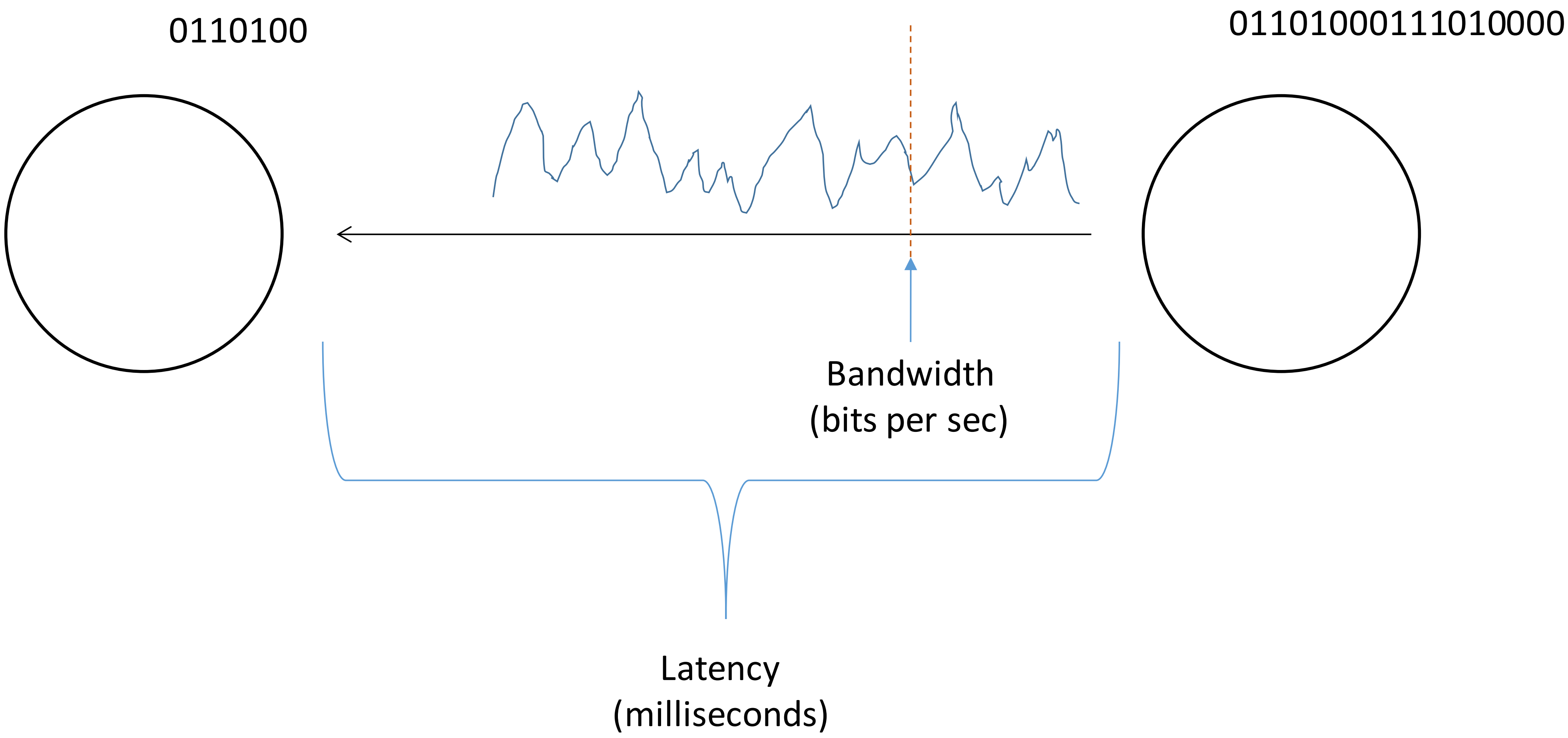
Today

- We start with a sweeping overview of the Internet
- To keep it at an appropriate level, I simplify most everything
  - The actual Internet is more flexible/general than what I show, but…
  - The key ideas shown here are the key ideas
- The survey is “bottom up”
- The course material is “top down”

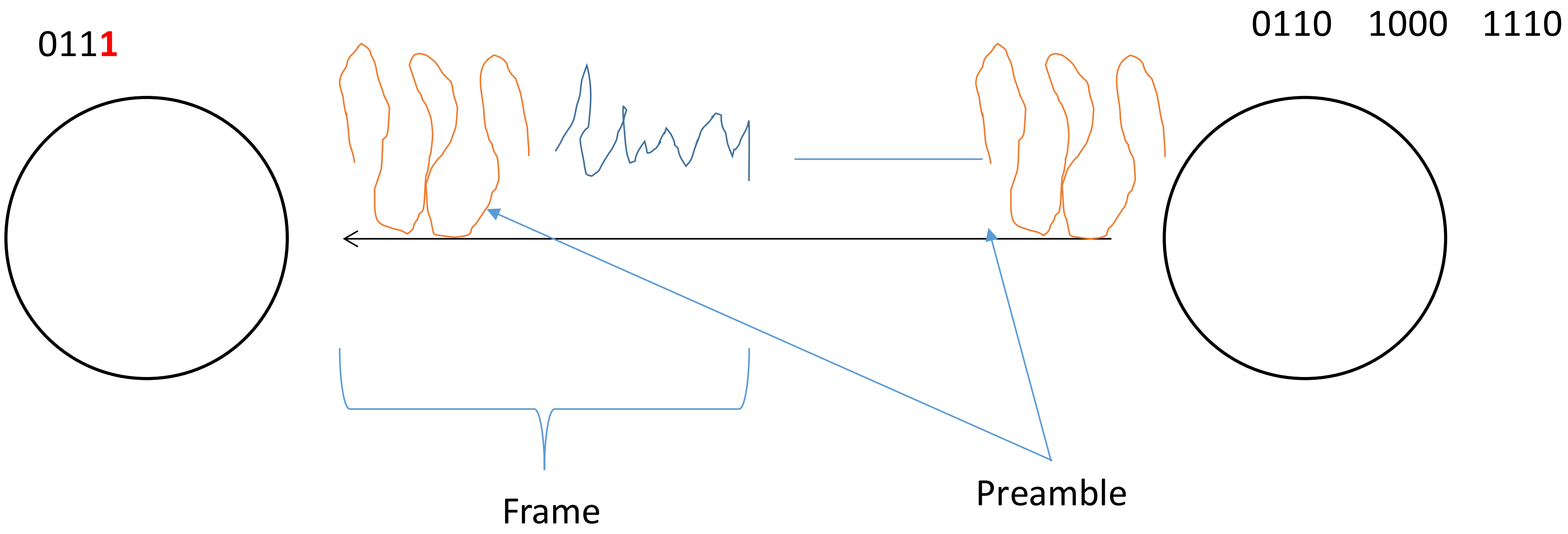
Basic Concepts and Terminology - Link



Basic Concepts and Terminology - Performance

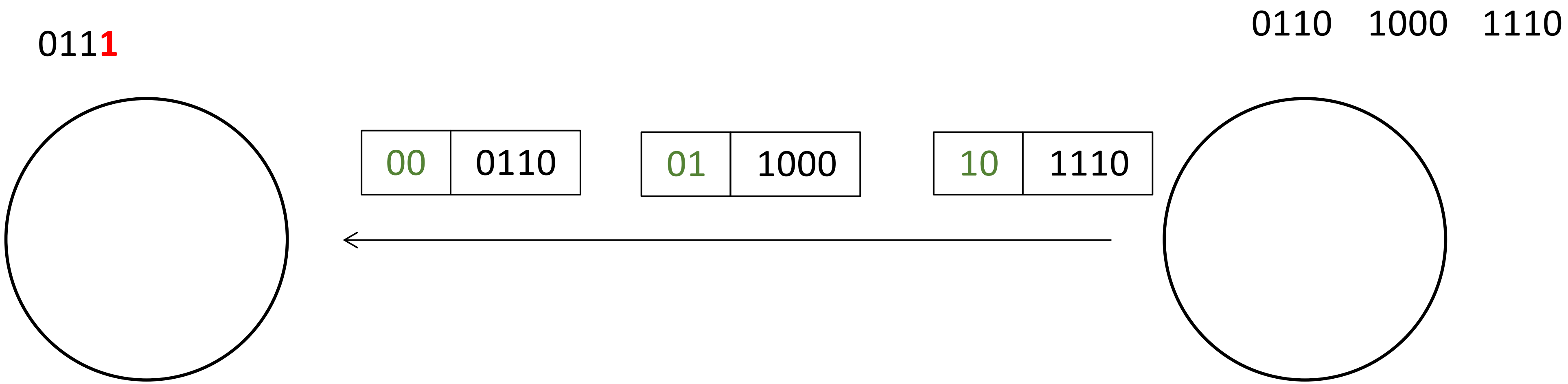


Basic Concepts and Terminology - Framing



- *Frames provide boundaries so the receiver can know when the source has something to say and when not.*
- *Frames boundaries are useful when there are errors. A frame is corrupt, but not the entire data stream*

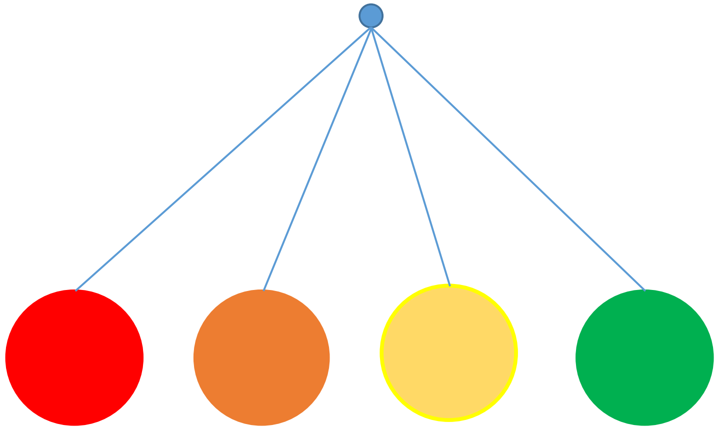
Basic Concepts and Terminology - Header



- The *frame header* contains information the sender wants to transmit to the receiver that is not part of the data stream
- In this example, we're transmitting sequence numbers
  - Why?

- Headers are communication between the sending and receiving protocol implementations
- Data is communication between sending and receiving protocol clients (apps)

Basic Concepts and Terminology- LAN

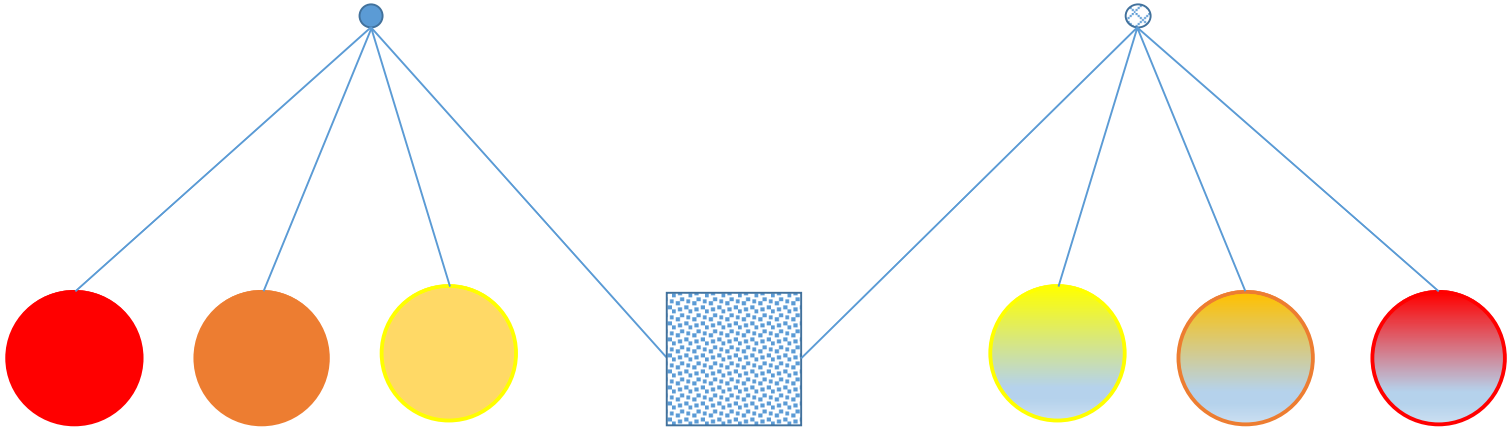


- A *local area network* (often just called “a network”) is an ensemble of nodes who can hear each other’s transmissions
  - When red transmits, orange, yellow and green all hear the bits
- Now need more information in the header
  - Source *address* (name)
  - Destination *address*
  - *(This description corresponds to MAC addresses)*

- Note that the addresses are just unique names
  - I know my name is 18344933830223928288.
  - When I see a frame addressed to that name, I act on it.
  - If I see a frame addressed to any other name, I ignore it.

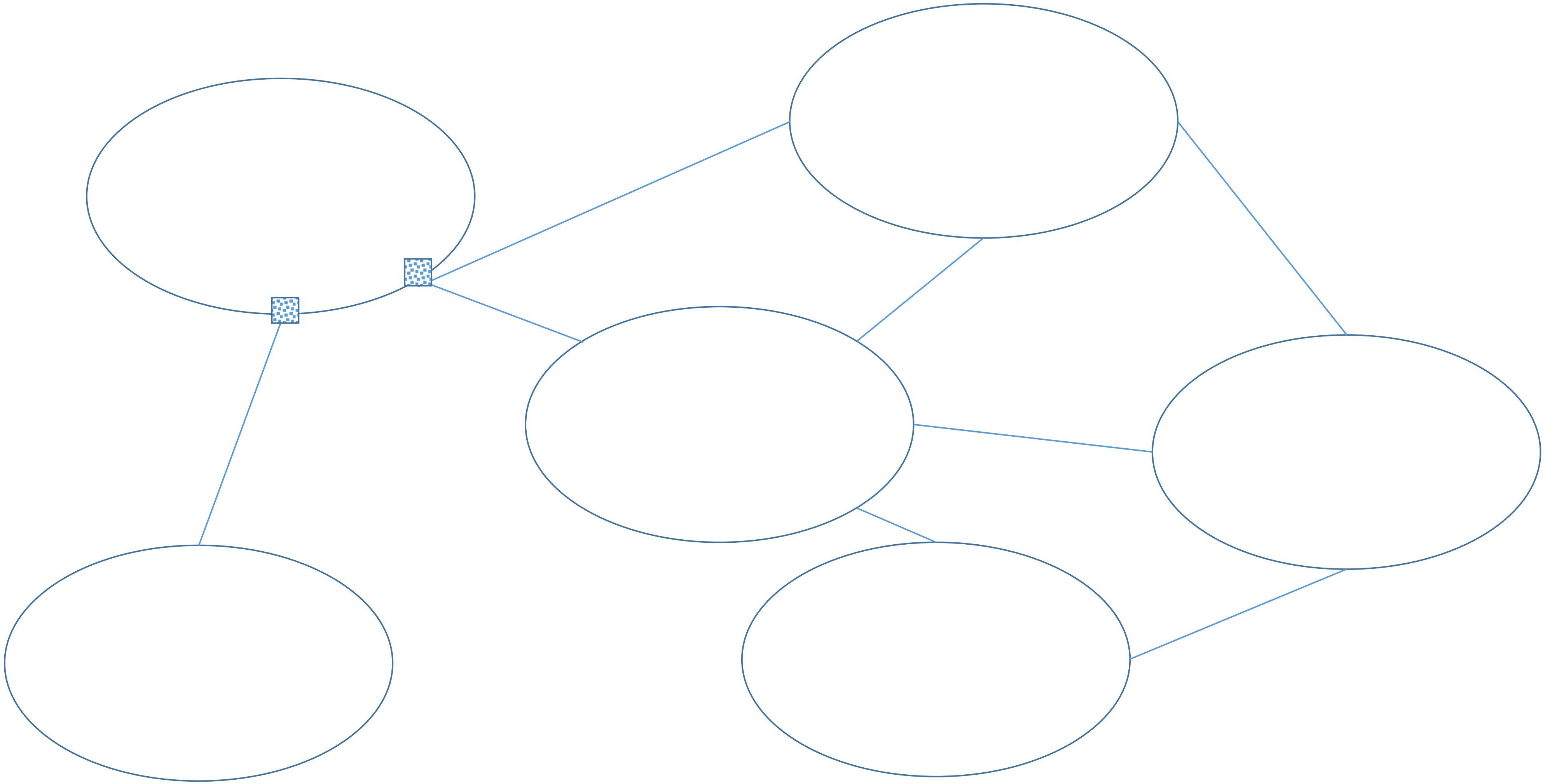
- This works because every transmission is sent to every destination

Basic Concepts and Terminology- Router

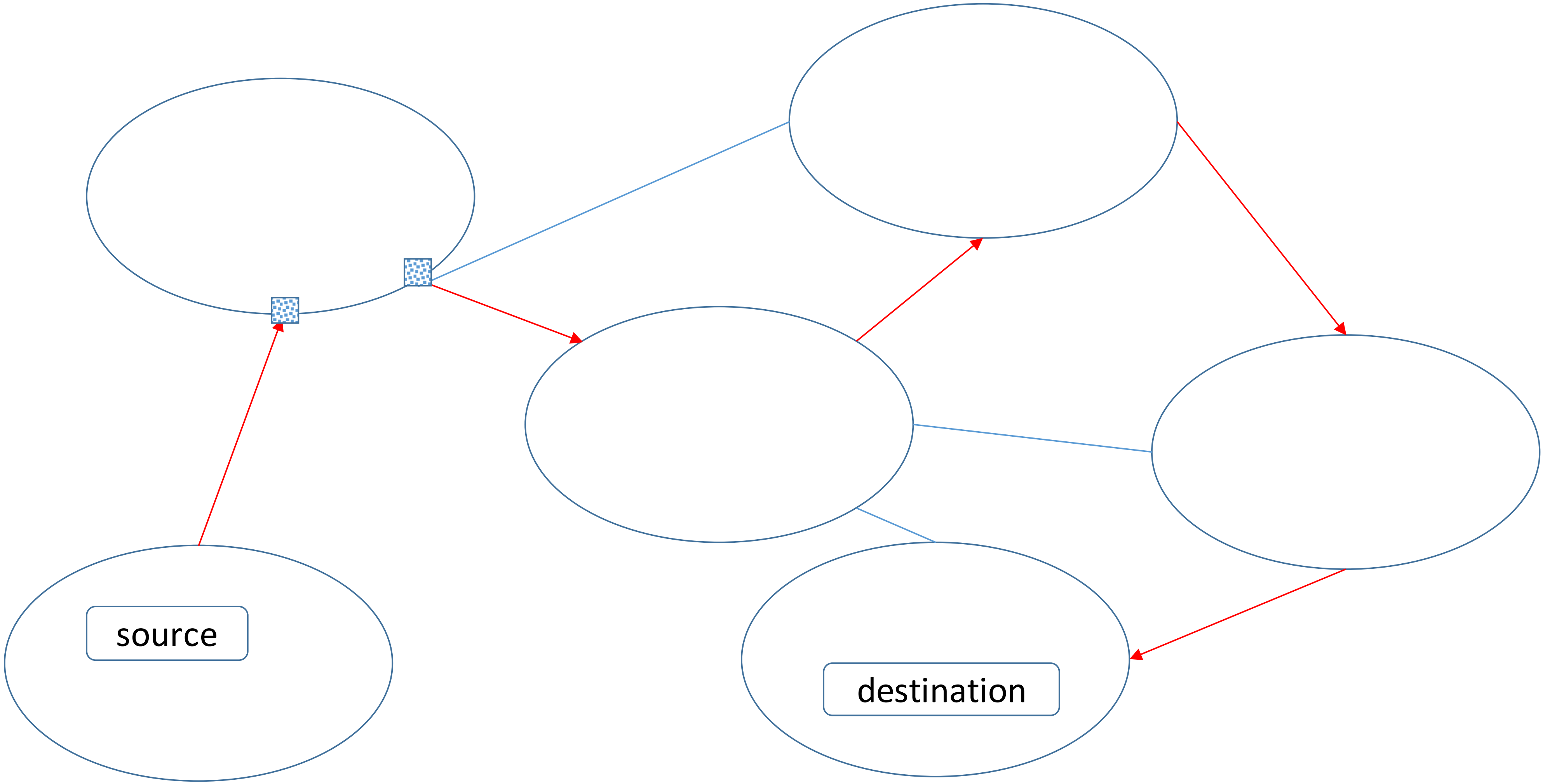


- Routers sit on two or more networks
- Each LAN can achieve host to host delivery within the LAN as always
- The router notices when a “packet” sent in the solid network is destined for the hash network
  - It copies the packet onto the other network
  - It doesn’t copy packets that don’t traverse networks

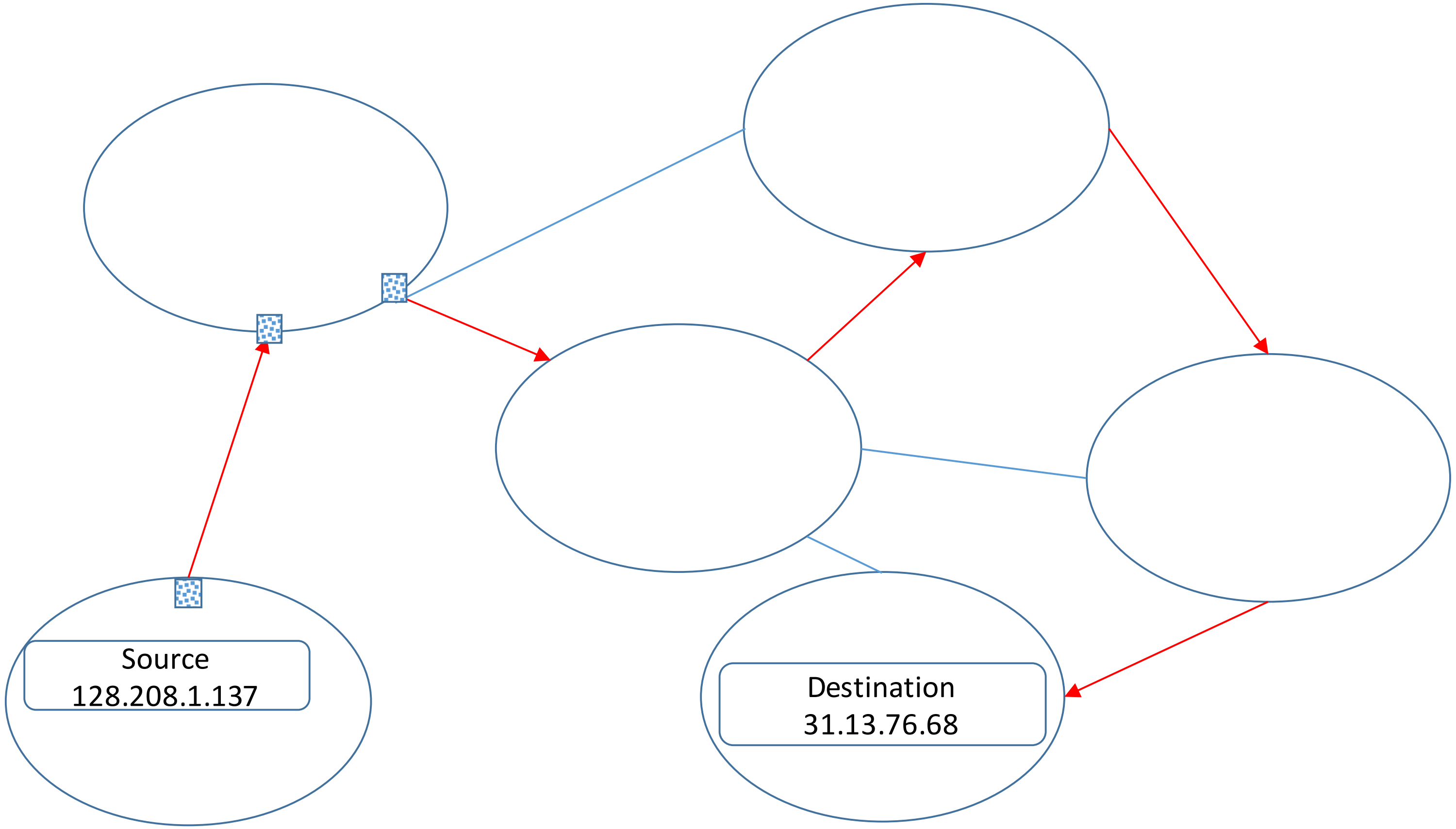
Basic Concepts and Terminology- Internet



Basic Concepts and Terminology- Routing



Basic Concepts and Terminology- IP Address

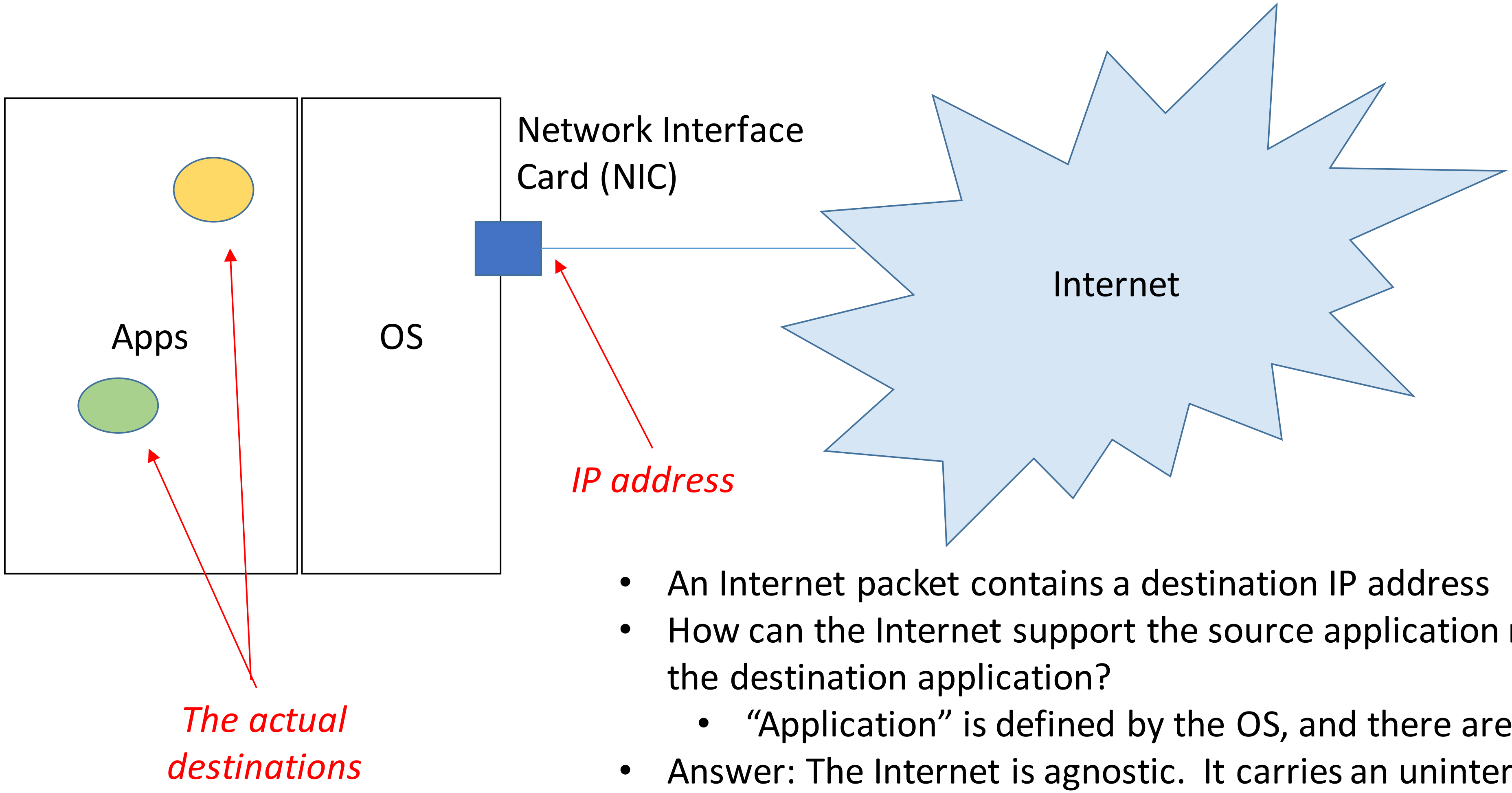


- MAC addresses are just UIDs
  - No useful structure
- To route efficiently, we need addresses that have some locality
- That's what IP addresses are for

- IP addresses name network interface cards (roughly, hosts)

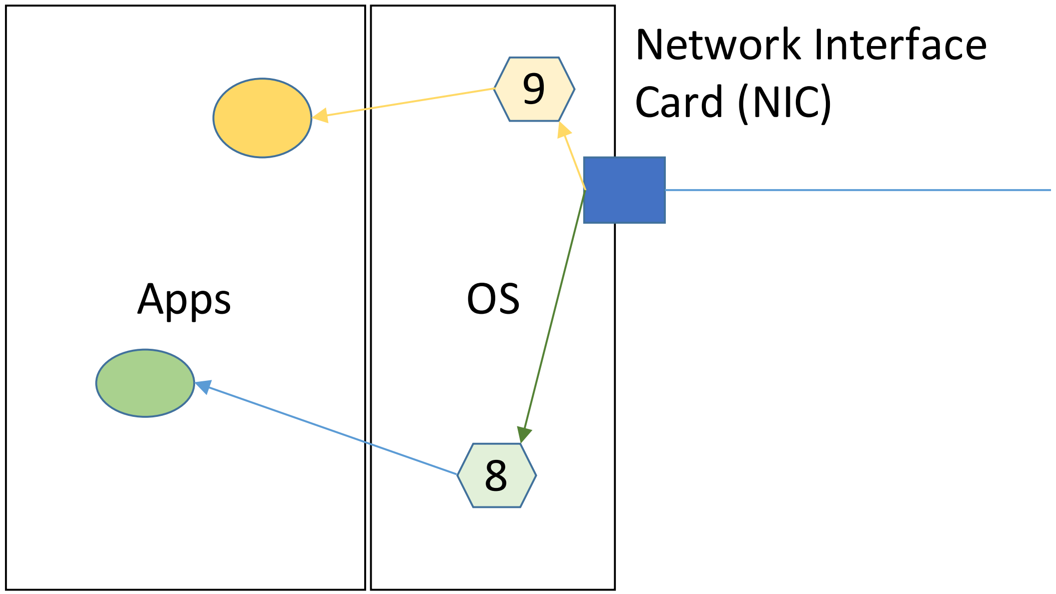
- The IP address space is global (mostly)
- Addresses that are "similar to" each other are located in the same LAN
- The lower left LAN has a "gateway"

Basic Concepts and Terminology- IP Address



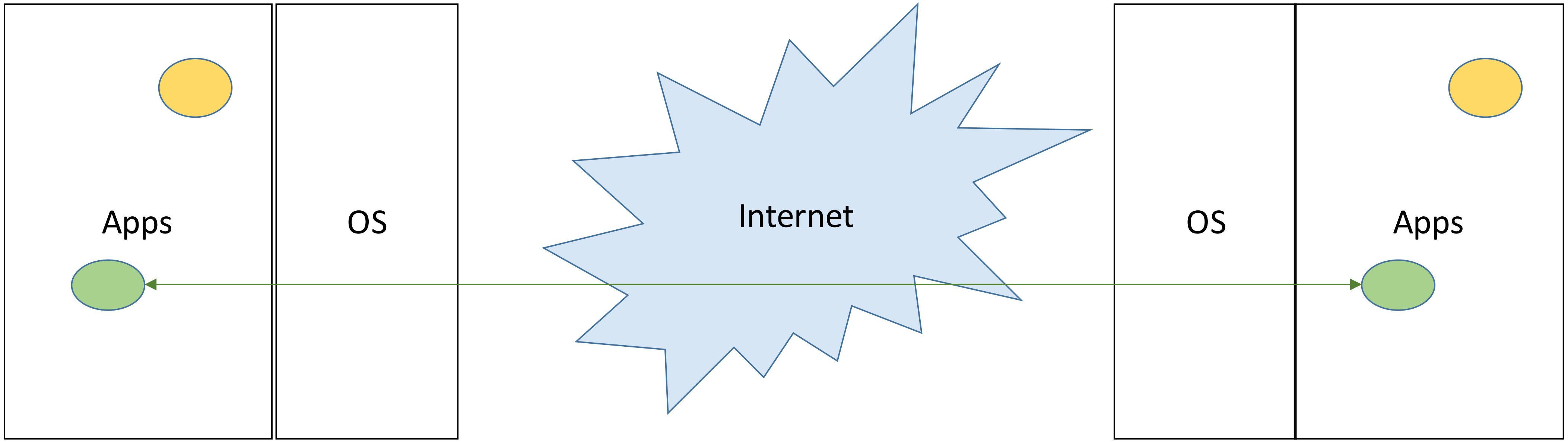
- An Internet packet contains a destination IP address
- How can the Internet support the source application naming the destination application?
    - "Application" is defined by the OS, and there are many
- Answer: The Internet is agnostic. It carries an uninterpreted ID (an integer), called a *port*
- The scope of the port name is the host (IP address)

Basic Concepts and Terminology- Berkeley Sockets



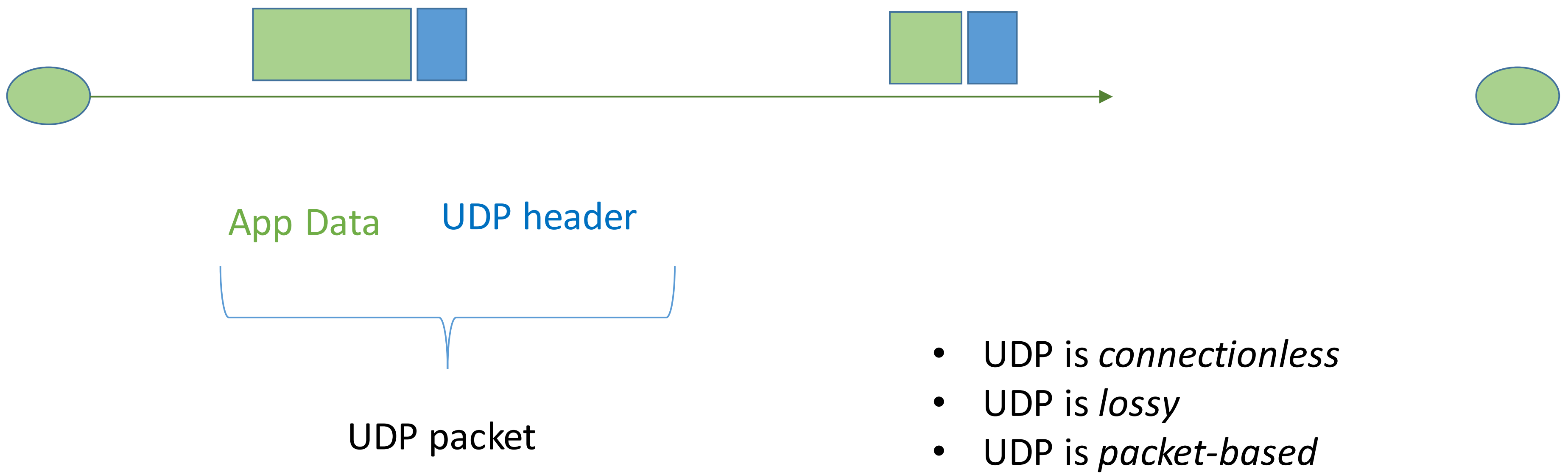
- Application creates a *socket*, which is an OS managed resource
  - Nothing to do with the Internet…s
- Application *binds* the socket to a port (a small integer in a restricted range)
- Incoming Internet packets give both the IP address of this node and a port number as the destination
- The OS looks for a socket bound to the port
- If there is one, it puts the packet into the receive buffer of that socket
- When the application does a *read* from the socket, it fetches packets from the socket's input buffer

Basic Concepts and Terminology- Transport Protocol



- A transport protocol carries uninterpreted bytes from a source application to a destination application
- Internet transport protocols are “*end-to-end*” – their implementations are in the ends hosts, not the hardware of Internet itself

Basic Concepts and Terminology- UDP



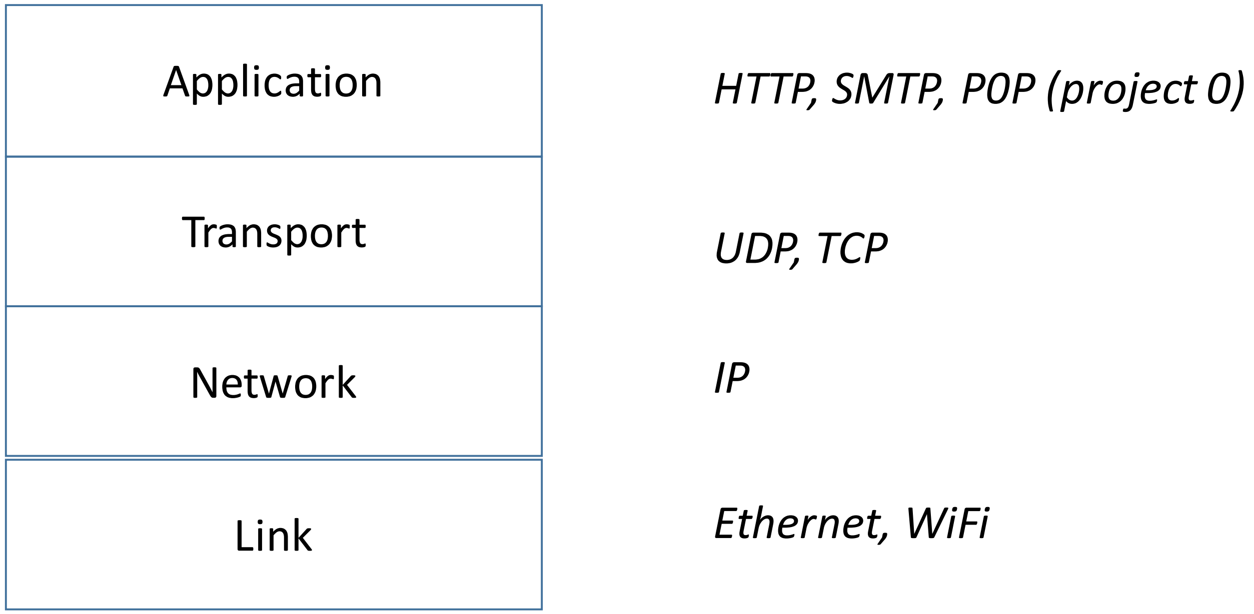
- UDP is *connectionless*
- UDP is *lossy*
- UDP is *packet-based*
  - Provides app message framing
  - So long as msg isn't too big

Basic Concepts and Terminology- TCP

- TCP is *connection based*
- TCP is *reliable*
- TCP is *stream-based*
    - Reading from a stream is similar to reading from a file

Internet Reference Model - Layering

- The classic OSI model has seven layers
- In practice, there are more like four



Basic Concepts and Terminology-Protocol

- A *protocol* is a set of rules governing how information is exchanged
  - It includes how information is encoded
  - It includes the definition of valid message exchange sequences

- The other end of a communication is presumed to be following the protocol
  - That allows each node to infer some information about the state of the other party/parties

Unrealistically Simple Example Protocol - USEP

- This protocol moves data from A to B, unreliably

- Sender:
  - Sends successive messages containing successive data
  - Each message contains a header
  - The header contains a *sequence number* – 0, 1, 2, ….

- Receiver:
  - Initializes a *next expected sequence number* variable to 0
  - When message arrives compares its seqno to next expected
    - seqno < next expected: ignore message
    - seqno == next expected: accept message; increment next expected
    - seqno > next expected: detect message loss(es); accept message; next expected = seqno + 1

USEP Questions

- Is the situation seqno < next expected possible?
- Is it possible to see the same seqno more than once?
- Why doesn't the receiver just allocate a huge buffer and fill it with message contents as they arrive?
  - That is, allow messages to arrive in order 0, 3, 7, 4, 2, 1, 6, 5, for instance
- How does the receiver know when it has all the data?
- How does the receiver know when there's a new sender wanting to start a new transfer?
- What does sender end up knowing about what data actually arrived?

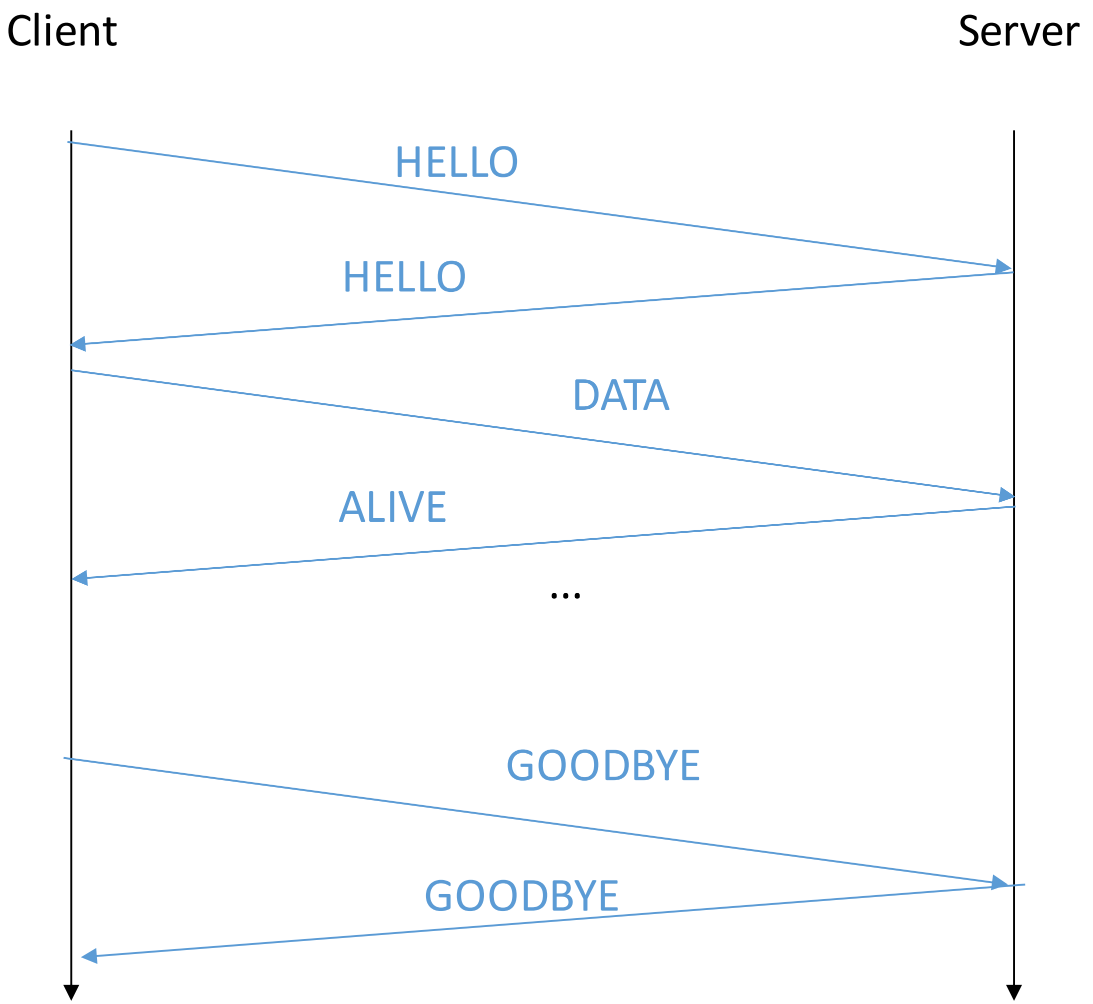
Example Application Protocol – POP

- Client-server protocol
  - When client wants to start, it contacts the server
- Objective: simple, unreliable, data transfer
- Message format:

magic	version	command	seqno	session id	data payload
16 bits	8 bits	8 bits	32 bits	32 bits	variable

- Commands are: HELLO, DATA, ALIVE, and GOODBYE

POP Protocol Sequence Diagram

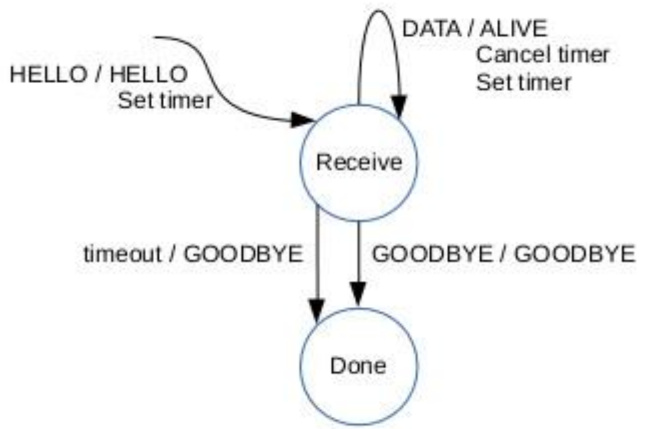


- HELLO exchange sets up a new “session”
  - Client picks a UID for the session
    - How?
- Client sends successive data payloads
  - ALIVE responses reassure client
- GOODBYE exchanges allows clean shutdown’
- What happens if a message is lost?

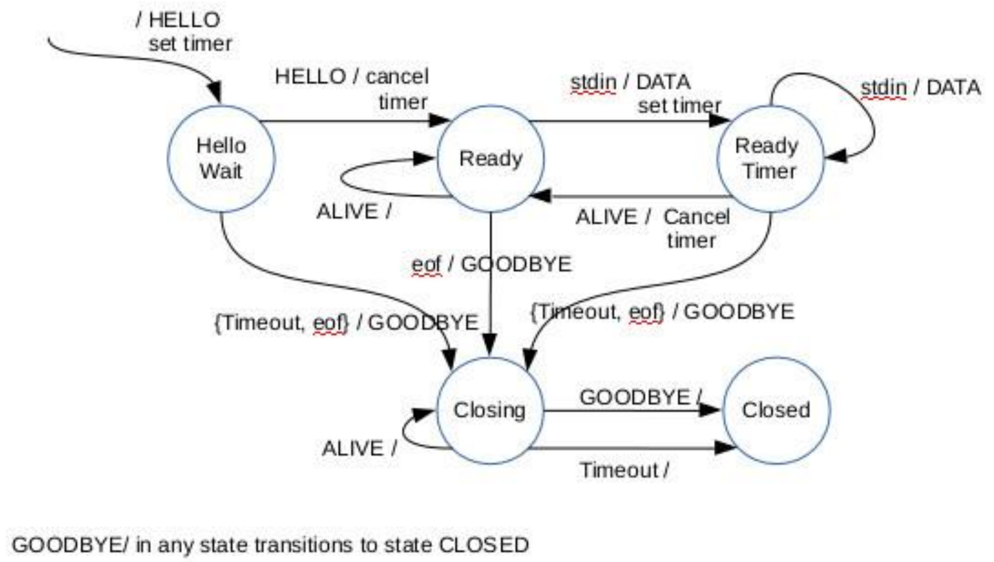
Lost Message - Timeouts

- It **is** possible for the sender to know that a message was received
  - The sender receives a message that would have been sent only if its message was received (assuming the other end is following the protocol)
    - Example: If the client sends an HELLO, it knows it was received when it gets back an HELLO
- It isn't possible to know that a message wasn't received
  - Why can't receiver send a message saying "I didn't get it"?
- A common approach to guessing when a message is lost is a timeout
  - Send, wait for reply, if it doesn't come "after a while," act as though it was lost

POP State Diagrams



Server
(per-session state)



Client