CS 3640: Introduction to Networks and Their Applications

Fall 2023, Lecture 1: Administrivia and The Internet Layers

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Teaching Assistant: Manisha Keim

Today's class

1. Course policies and administrivia

2. What is the Internet?

3. What's next in this course?

Rules of engagement: Seating arrangement

- **Peer learning is a big part of this class.**
  - Being able to discuss topics with your peers in real time improves understanding and retention of complex material.
  - Every lecture will have 2-3 discussion prompts.

- **Not everyone may feel comfortable being in a small group (verbal) discussion. That's OK.**
  - You may opt to sit out these discussions if you wish --- just write your thoughts down on paper and share them when (if) called upon.

Rules of engagement: Congeniality

- **3/5 assignments are group projects.**
  - Be professional (on time and responsive).
  - Be understanding (seek to understand before being understood).
  - Collaborate and be helpful (teach others what you know).

- **You will need to work well with your peers to do well in this class.**
  - Peer feedback forms a part of your grade.
  - After each group assignment, your peers will evaluate your performance and leave comments about the quality of your participation. These will be (anonymized and) shared with you at the end of the term.

Rules of engagement: Interaction

- **Computer networking can be a very fun and intuitive subject.**
  - Often, the simple idea you have is the way things actually are!
  - Vocalize your intuition or simple ideas in class.

- **Ask questions and answer questions.**
  - If you don't understand something, then that's enough of a reason for me to re-explain it. Ask questions when something is unclear.
  - I don't enjoy giving "lectures" and I like classroom interactions.
    - I will ask a lot of questions in class.
    - I thrive in awkward silences, and I have no problem waiting for an answer. (Raise your hand if you have an answer).

Course material: Textbooks

- **No textbook needed**
  - Slides and other (free) useful resources will be provided on ICON.
  - Good book to have around, but not needed: Kurose & Ross "Computer Networking: A Top-Down Approach"

Course material: Assignments

- **5 assignments will make up 65% of your grade.**
  - 3 group assignments: Make your own teams (min: 1, max: 5, recommended: 3). Contact me if you need help finding teammates.
  - Teams need to be declared before the lecture after the assignment is handed out.
    - You may switch teams only between assignments.
- **Assignments will be very challenging. Start early.**
- **Non-participation in group assignments.**
  - Will result in a viva-voce with the instructor. Failure will result in 0% for that assignment.

Course material: Exams

- **Two exams: Mid-term and final**
  - Each will count for 15% of your grade.
  - Multiple choice questions aimed at testing understanding. These will not test memory.
  - Key to success: Pay attention in class and think deeply about the discussion questions.

Course policy: Academic dishonesty

- **Policy: Don't do it. It isn't worth it.**
  - Automatic 'F'. Will be reported and may result in expulsion (worst case) or a fine/mandatory 20-hour course (best case).

- **What is academic dishonesty in this course?**
  - Copying from other students/groups. (Also: Allowing copying)
  - Copying from any other source without attribution.
  - Passing off the work of others as your own (includes paid work).

- **What is not academic dishonesty?**
  - Discussing ideas with others in this class.
  - Sharing tips and tricks about how a problem might be solved.

Course policy: Late submissions

- Penalty of 10% for each day that your assignment is late.
- Extraneous exceptions are permitted: If you/someone on your team has challenges that prevent on-time submissions, let me know and we'll work together to find a solution.

- **Group assignments: One submission for the entire group. Submission clearly indicates group members and their individual contributions.**

Where do I get …

- **detailed policy, slides, logistics, assignments, references?**
  - ICON
  - Updates will be made by noon every Tuesday and Thursday.

Where do I get …

- **support and help with material?**
  - Rishab's office hours (see ICON).
  - Manisha's office hours (see ICON).
  - Peer support: Piazza discussion board.
    - Participation points for insightful posts/comments/questions/answers.

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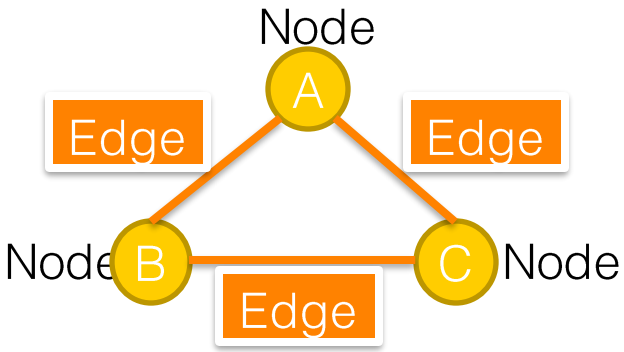
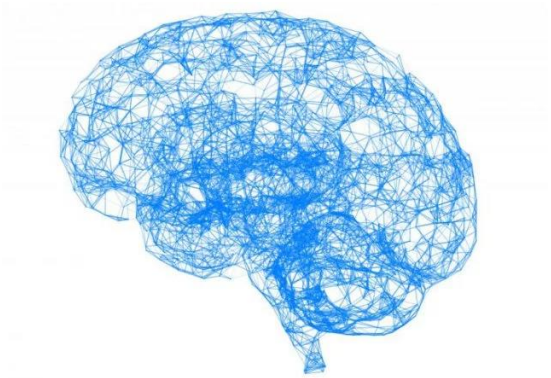
What is a network?

- An arrangement of lines that connect points.

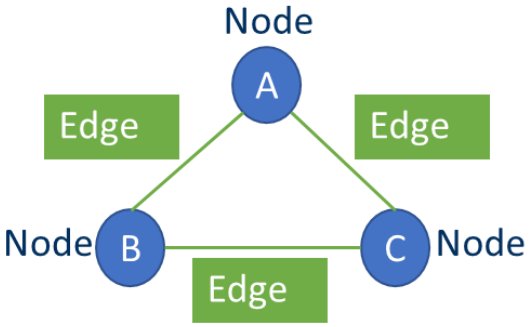


Examples and goals of networks



- Goals: Resource sharing and communication.
- **Discuss: What makes a good network?**
  - Well connected, high capacity, affordable, etc.

What is a computer network?



- A network of computing devices.
  - Nodes: Computing devices.
  - Edges: Transmission media.
  - Goal: Communication and resource sharing between devices.
- Examples: Cellular networks, Wi-Fi, ethernets, etc.

Computer networks

Each network uses a **specific type of transmission media** to interconnect a set of devices.

What is the Internet?

The Internet is not a specific network.

The **Inter**net ties different networks together.

What is the Internet?

- The Internet facilitates communication between many different networks.
  - It does so by providing a set of protocols to facilitate communication between different networks.
  - It allows you (on a university ethernet network) to talk to your friend (on a home Wi-Fi network).

Design goals: Networks vs. The Internet

- Design goals of a computer network:
  - Speed, cost, reliability, etc.
  - Achieved through engineering.
    - How should this task get done?

- **Discuss: Design goals of the Internet**
  - Interoperability, scalability, fault-tolerance, etc.
  - Achieved through architectural design.
    - What tasks have to get done? Who should do them?

Let's design a messaging app

- Scenario: No Internet.
- Three users:
  - User A: Ethernet
  - User B: WiFi
  - User C: 5G cellular
- **Discuss: What protocols would you need to implement to build this app?**

Let's design a messaging app

- Things you would need to do:
  - You'd have to design a way for your app to use ethernet, WiFi, and 5G.
  - You'd have to keep adding new technology support and maintain existing code.

- All of that sounds like a lot of work for every new app/user/technology. How does the Internet make this easier?

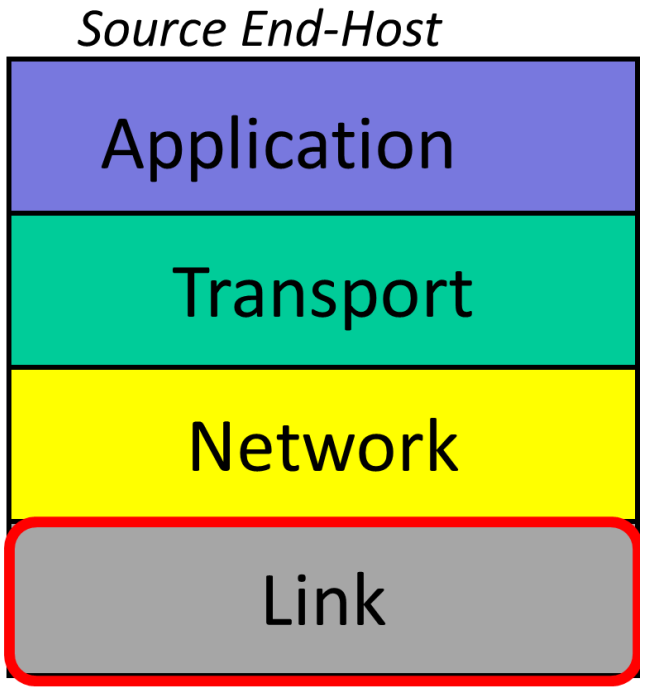
Idea: abstraction/layering

- The Internet has a hierarchy of operations.
  - Examples of operations: writing to a medium, finding a device in a network, etc.
  - Many of these are common to every app.
  - If we made the design modular, we could easily reuse them.

- If we made layers, each operation could go in a layer.
  - Each layer could provide this operation as a service to a higher layer.

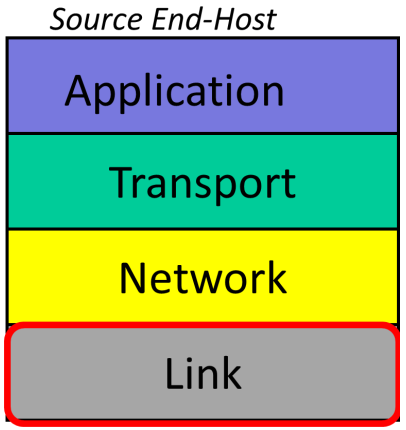
The 4-layer Internet model

- If we made layers, each operation could go in a layer.
  - Each layer could provide this operation as a service to a higher layer.



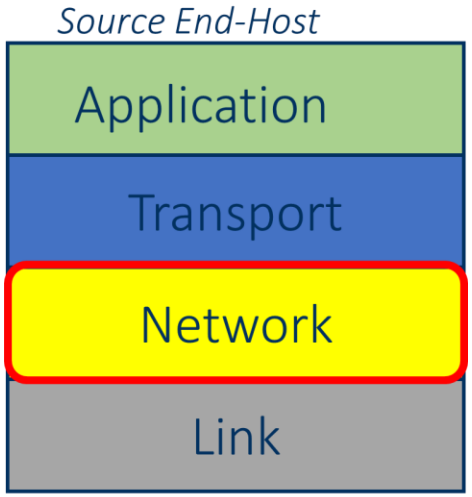
The link layer

- Links connect end devices (phones, laptops, etc.) to network gateways (routers).
- Links connect network gateways to each other.
- The link layer is responsible for sending bits over a link.
- The link layer is used as a service by the network layer.

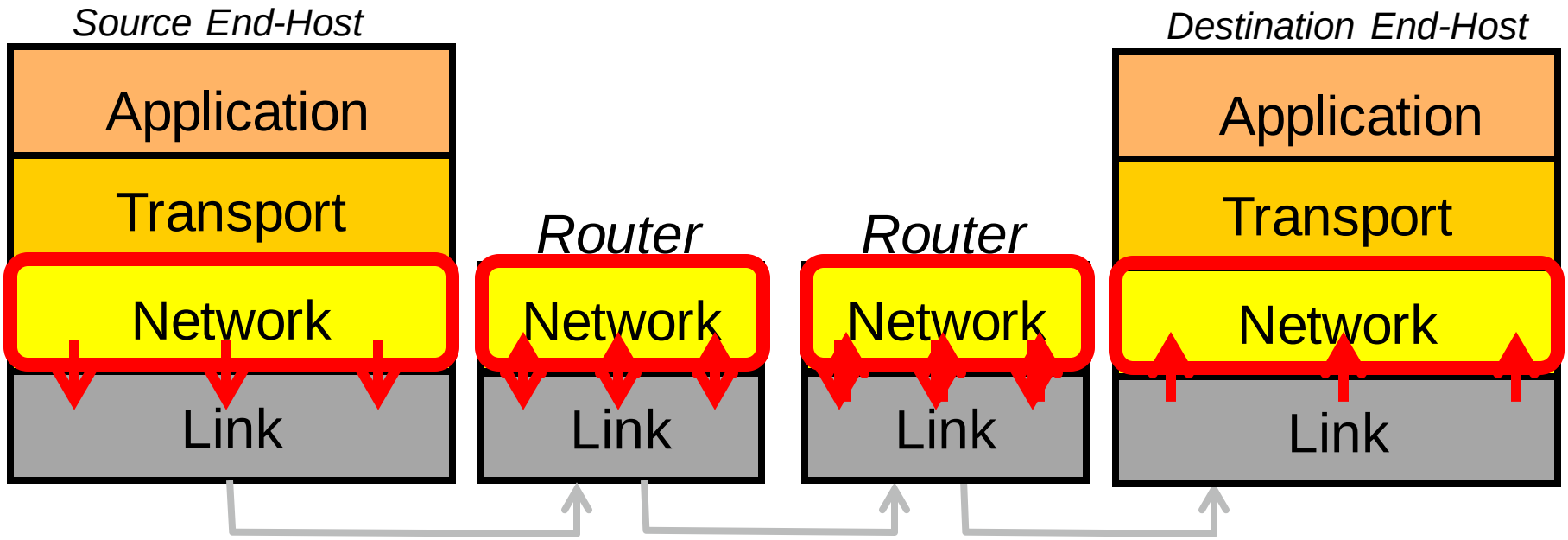


The network layer

- **The network layer provides an "end-to-end" (source to destination) service.**
  - Job: It delivers packets from the source to the destination. It does so by using the link layer as a service.
  - How?
    - It figures out what the next hop should be and tells the link layer to send it there.
    - **It doesn't care how data gets to the next hop. That's a job for the link layer.**



The network layer



The network layer

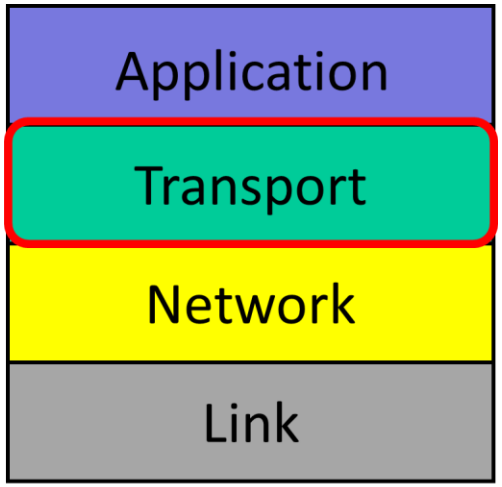
- There is only one network layer protocol **for data delivery**: The Internet Protocol (IP).
  - It is the glue of the Internet. There is no Internet without IP.
  - Internet Control Message Protocol (ICMP) is only for error and diagnostic functions.

- IP makes no promises that datagrams will reach the destination:
  - uncorrupted.
  - in the order they were sent.
  - at all.

- **Discuss: Why would the Internet Protocol work this way?**

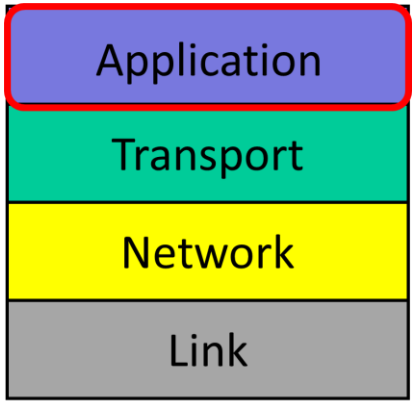
The transport layer

- Interface between the application and the network layer. It implements:
  - Reliable delivery, in-order delivery, congestion detection, and congestion control (if required).
  - **Discuss: In what scenarios would these not be required?**
- Makes network communication appear like inter-process communication for applications.
- Examples: TCP (Transmission Control Protocol) and UDP (User Datagram Protocol).



The application layer

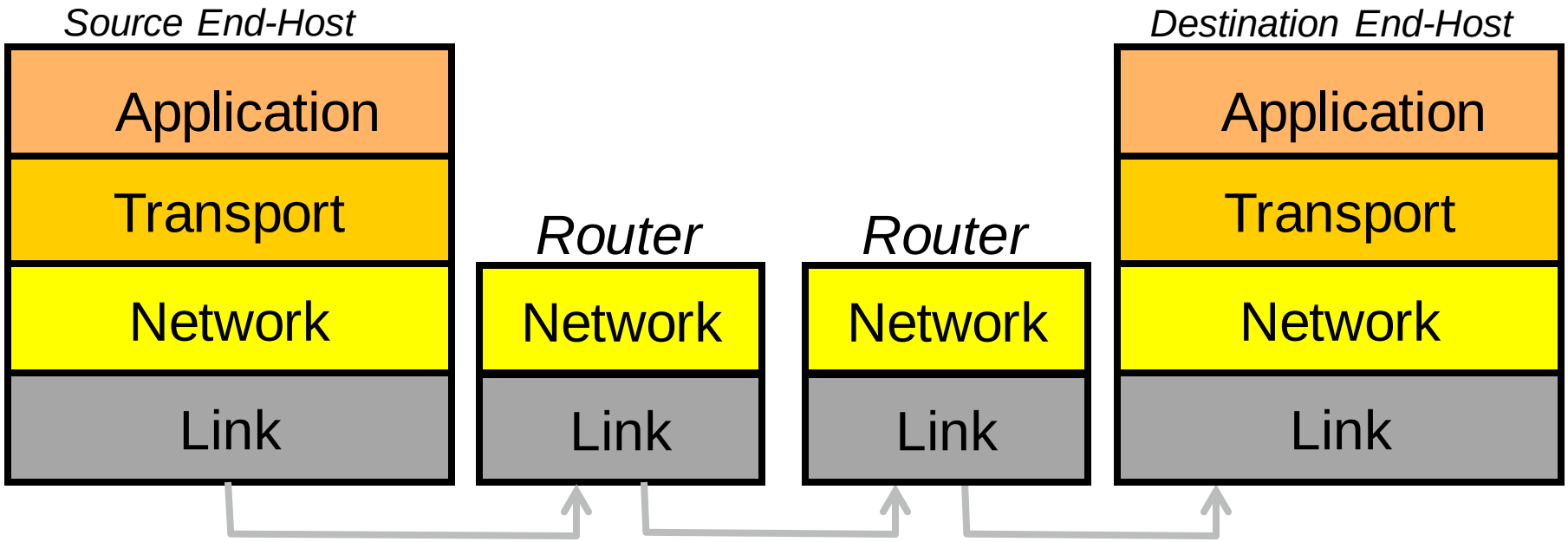
- This is where the networking logic for your application goes.
  - Example: How should data meant to be transferred be structured? How should this data be interpreted by the receiver?
    - Web apps rely on the HTTP application layer protocol for communication between two hosts.



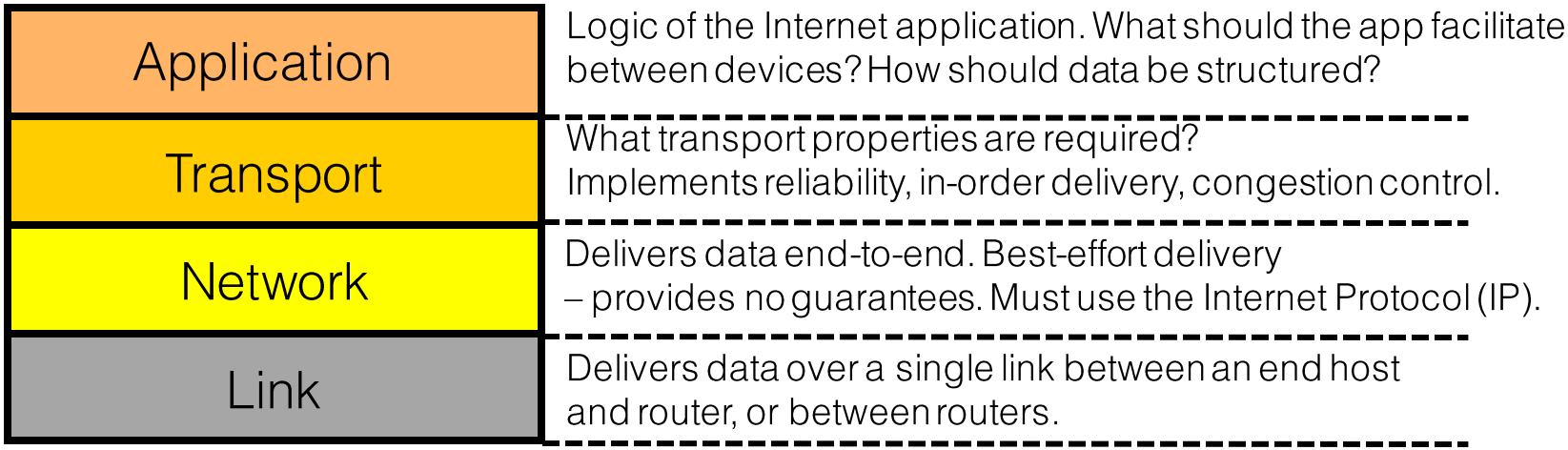
- Every app is different, but they all only need to use the network through the Transport layer abstraction.

- You rarely must write any code below this layer to make an Internet application!
  - Developers are insulated from the constant evolution of networking technology and protocols.

Putting it all together



Summary of the 4-layer Internet model



Let's design a messaging app

- Scenario: The Internet abstraction exists.
- Three users:
  - User A: Ethernet
  - User B: WiFi
  - User C: 5G cellular
- **Discuss: What protocols would you need to implement to build this app?**

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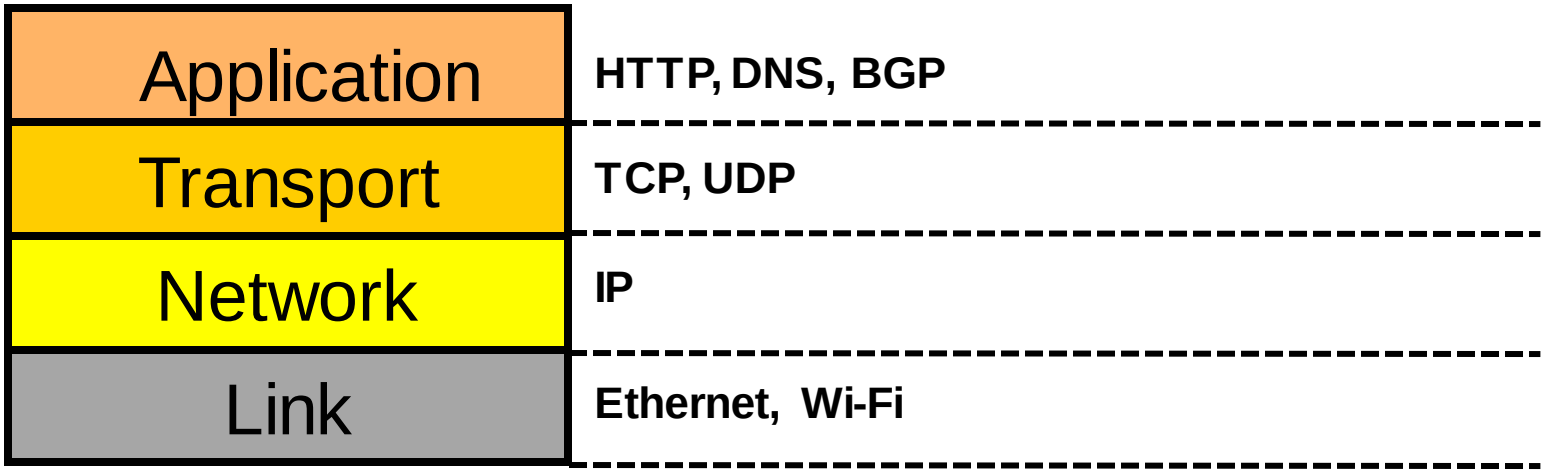
High-level description of content

- Internet architecture
  - What are the principles driving Internet design?
- Engineering and protocols
  - How are these principles implemented?
- Protocol overloading
  - How are implementations exploited?
- Economic, legal, social, and ethical considerations
  - Ongoing challenges and things to think about as computer scientists.

Tentative list of protocols



TODOs

- Get on Piazza and introduce yourself to me and your peers.

- Start assignment 1 (linked on ICON syllabus page).
  - Due: Aug 31 @ 11:59pm