CS 43: Computer Networks

01: Course Administration & Introduction

September 3, 2019

Sit toward the front and next to other students!

Today

- What is this course about?
- Course Administration
  - Structure & Grading
  - Academic Honesty
  - How does this class work?
- Introduction
  - What does it take to transmit a packet over the Internet?

What This Class is about

- How networks (focus on the internet) work
- How applications that use networks work:
  - HTTP, Email, DNS, etc.
- How to write programs that communicate over networks
- How different protocols, policies, and mechanisms interact to provide an effective communication medium

Instructor: Vasanta Chaganti

Please call me Vasanta or Prof. Chaganti

Research interests: Network performance and privacy

- measure the performance of network protocols
- what does your network data reveal about you?

Office Hours
Office: SCI Center 252D

- Mondays: 2.30 – 4.30 PM
- Fridays: 10 - 12 PM
- By Appointment

Lab Instruction: Charlie Kazer

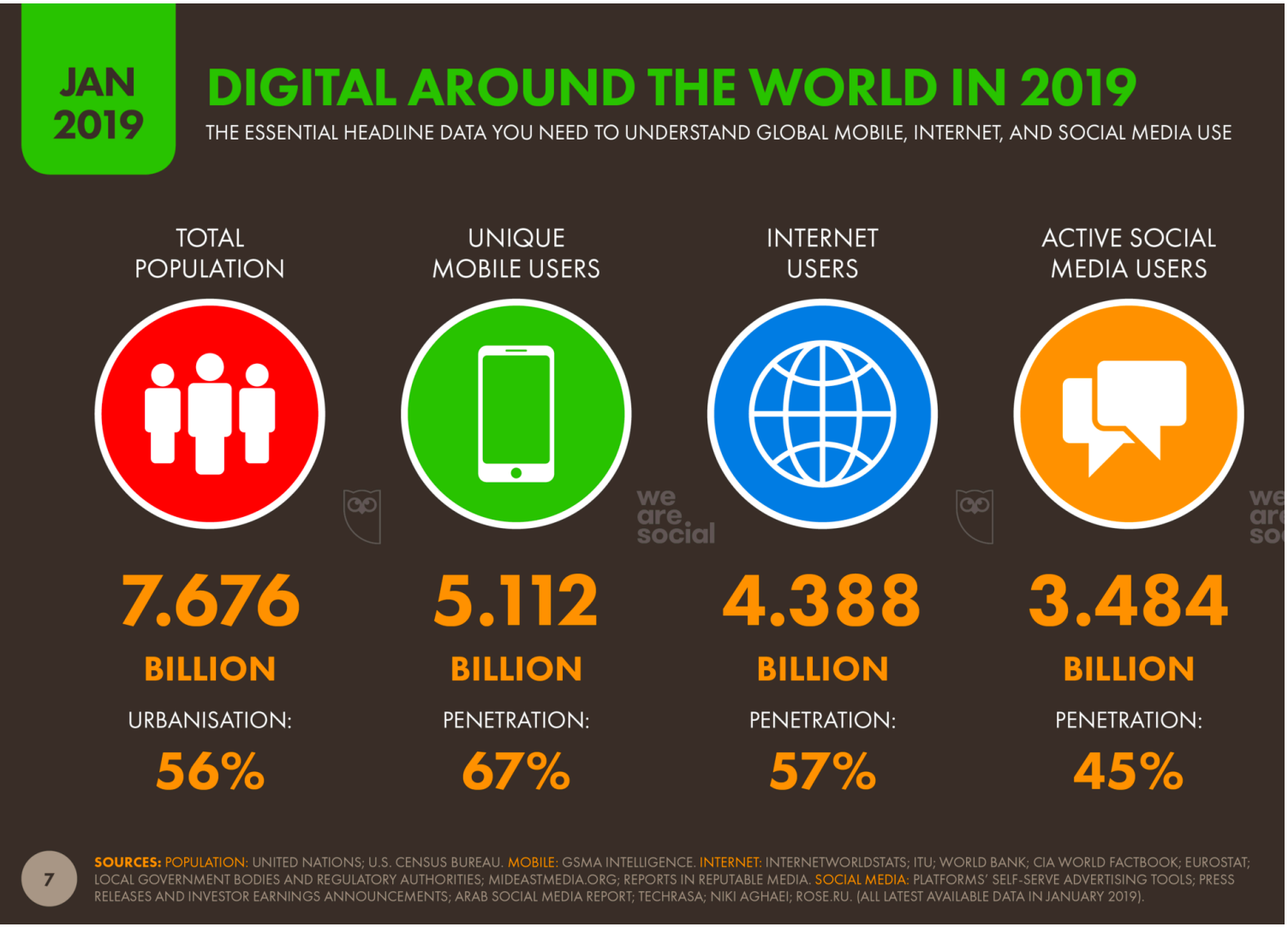
Office Hours
Office: SCI Center 252B

- Tuesdays: 10.00 – 12.00 PM
- Thursdays: 4.00 – 5.30PM
- By Appointment

Research: data center networks and computer network simulation:
- “predict the behavior of large systems using observations of smaller systems”

The Internet is Exciting!

- Rapid growth and success.
  - 1977: 111 machines on Internet
  - 1981: 213
  - 1983: 562
  - 1986: 5000
  - 1989: 10,000
  - 1992: 1,000,000
  - 2001: 150 – 175 million
  - 2002: > 200 million
  - 2018: ~ 3 billion (>1B are phones/tablets)



https://datareportal.com/reports/digital-2019-global-digital-overview

Nearly 57% of the total global population of 7.6 billion are on the Internet!

The Internet is Exciting!

- Rapid growth and success.
- We're here at the beginning.
- Communication is empowering.

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- Rapid growth and success.
- We're here at the beginning.
- Communication is empowering.

Star Trek (Late 60s)

Video calls

We're here at the beginning..

- Most of the growth happened in our lifetime.
- Still TONS of untapped potential.

Founded 1998

Founded 2004

We're here at the beginning..

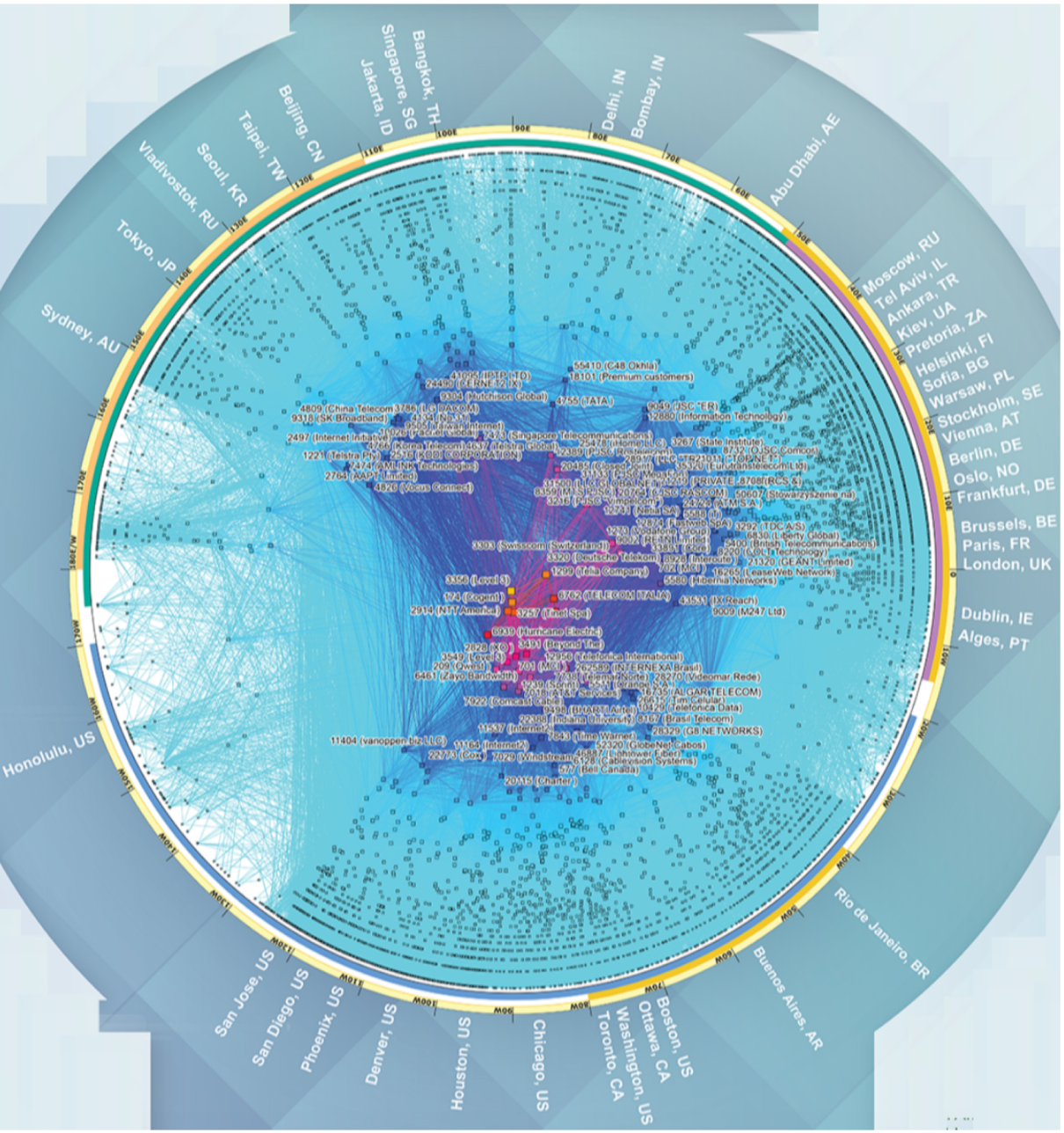
- Most of the growth happened <u>in our lifetime.</u>
- Still TONS of untapped potential.

Tweet-a-watt:
monitor energy use

Internet
refrigerator

sensorized,
bed
mattress

Web-enabled toaster +
weather forecaster



Internet traffic volume across the globe released by Cooperative Association for Internet Data Analysis (CAIDA)

Why should you care?

- To know how the Internet works
  - What may be wrong with your networks
  - When was the last time you went 24 hours without going online?
- Network programmers get respect
  - In high demand, get paid well

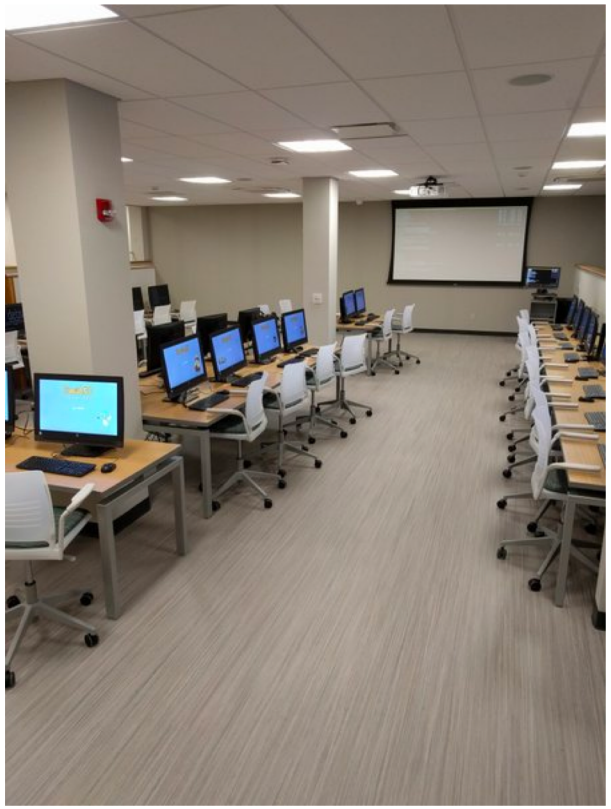
Pull back the curtain on the Internet

Dorothy and Toto pulling back the curtain in Wizard of Oz

Resources: Labs

- Github Enterprise: https://github.swarthmore.edu

- Lab sections:
  - Clothier 016 a.k.a pokemon lab
  - Wednesday 1:15-2:45PM, Wednesday 3:00-4:30PM



- slides on course website
- piazza: class recordings

Resources: Piazza!

- Piazza Q&A Forum
  https://piazza.com/swarthmore/fall2019/cs43/home

- All announcements will be on Piazza
  - Weekly in-class worksheets
  - Anonymized Grade Listing

- Use Piazza!
  - Your classmates benefit from your questions
  - Your classmates can answer your questions
  - We will check the forum frequently
  - Post publicly unless you have code in your question.

How does this class work?

This class is designed a bit differently:

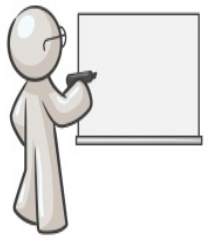
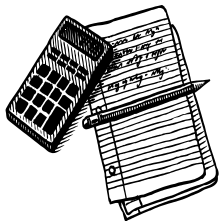
- Class will be centered around you
- Requires your participation

- Ever considered why we have lectures?

Traditional Lectures:

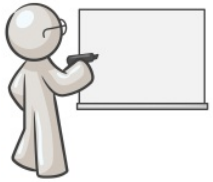
traditional model: an expert lectures to a small village

Traditional Lectures

Lecture	Textbook	Assignment	Exam
			
First Exposure	Read Hard Stuff	See if You Know Hard Stuff	Show Knowledge Mastery

<u>Little opportunity for feedback</u>

Interactive Classes with Peer Instruction

Readings	Worksheets	Instruction	Exam
			
First Exposure	Gauge understanding	Explore, add context, Provide feedback	Show Knowledge Mastery

- You do the “easy” part before class
- Class is reserved for interactive, customized experiences
- To learn, YOU must actively work with a problem and construct your own understanding of it

Peer Instruction: In-class discussions

- Based on readings for that day
- Individually think about the questions (1 -2 minutes)
- Discuss: Analyze problems with your group
  - (5 – 10 minutes)
  - Practice analyzing, talking about challenging concepts
  - Reach consensus
  - If you have questions, raise your hand and I'll come over
- Class-wide discussions Led by YOU (students) – tell us what you talked about in discussion that everyone should know!

Why Peer Instruction?

- You get a chance to think.
- I get feedback as to what you understand.
- It's more engaging!
- Research shows it promotes more learning than traditional lecture.

Clickers!

- Lets you vote on questions in real time.
- Like pub trivia, except the subject is always systems ☺

Clicker Registration

https://forms.gle/6zZne3agQGAA4aWu7

If you don't register your clicker, I can't give you credit for quizzes / participation!

Participation scores count from week 2

Locating your Clicker ID

Hexadecimal number: numbers 0-9 and letters A – F

ID is also visible when you turn your clicker on.

iClicker with Hexadecimal ID

Peer Instruction: iClickers

- Some discussion questions will involve iClickers

1. Solo vote: Think for yourself and select answer
2. Discuss: Analyze problems with your group
3. Group vote: Everyone in group votes
4. Class wide discussion:
   - Led by YOU (students) – tell us what you talked about in discussion that everyone should know!

Example Clicker Question

- Individual vote (think 1-2 minutes)
- Group discussion / group vote (5 minutes)
  - Room should be LOUD
- Class discussion

The best Hogwarts house to be in is..

A
Gryffindor

B
Slytherin

C
Ravenclaw

D
Hufflepuff

E: Something else (be prepared to discuss!)

Grading

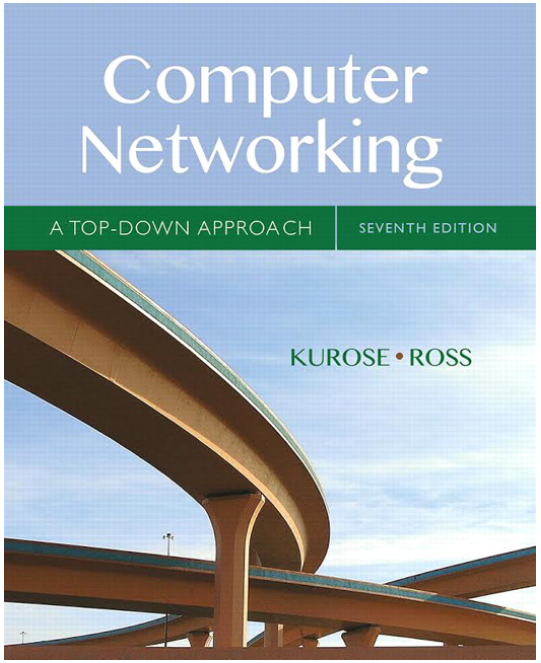
- 5% Worksheets / Reading Quizzes
- 5% Class participation (clicker questions)
- 25% Midterm Exam
- 30% Final Exam
- 35% Programming Assignments

Grading

- 5% Worksheets / Reading Quizzes
- 5% Class participation (clicker questions)
- 25% Midterm Exam
- 30% Final Exam
- 35% Programming Assignments

- I will drop your three lowest quizzes/no-shows.

Textbook



- Computer Networking: A Top-Down Approach (7th Edition)
- You need this book!

Policies

Genie (as William F. Buckley Jr)“ There are a few,..provisos, a, a couple of quid pro quos.” - in Aladdin

- Lab Lateness
  - 2 days of extra time for the semester (granularity of days)
  - Email AFTER you are done!
  - No Email: Grade whatever is present at the deadline.
  - up to 4 labs with the same partner

Policies: academic dishonesty

- Collaboration
  - **You may discuss approaches, not solutions**
  - You must submit your own work
  - Exams may include questions on programming
- Cheating
  - We take this very seriously. It can have a negative impact on your course grade, your GPA and your record at Swarthmore and beyond.
  - **Don't do it!**

Schedule

- Midterm: **Oct 22, In-class**.
  - Mark your calendar!
  - Let me know if this is a problem today!
- FINAL – TBA
- Labs:
  - Labs are held on Wednesday
  - Prev. Lab due on Tuesdays

Administrative Questions?

- All of this info on class website
- Feel free to ask on Piazza discussion board

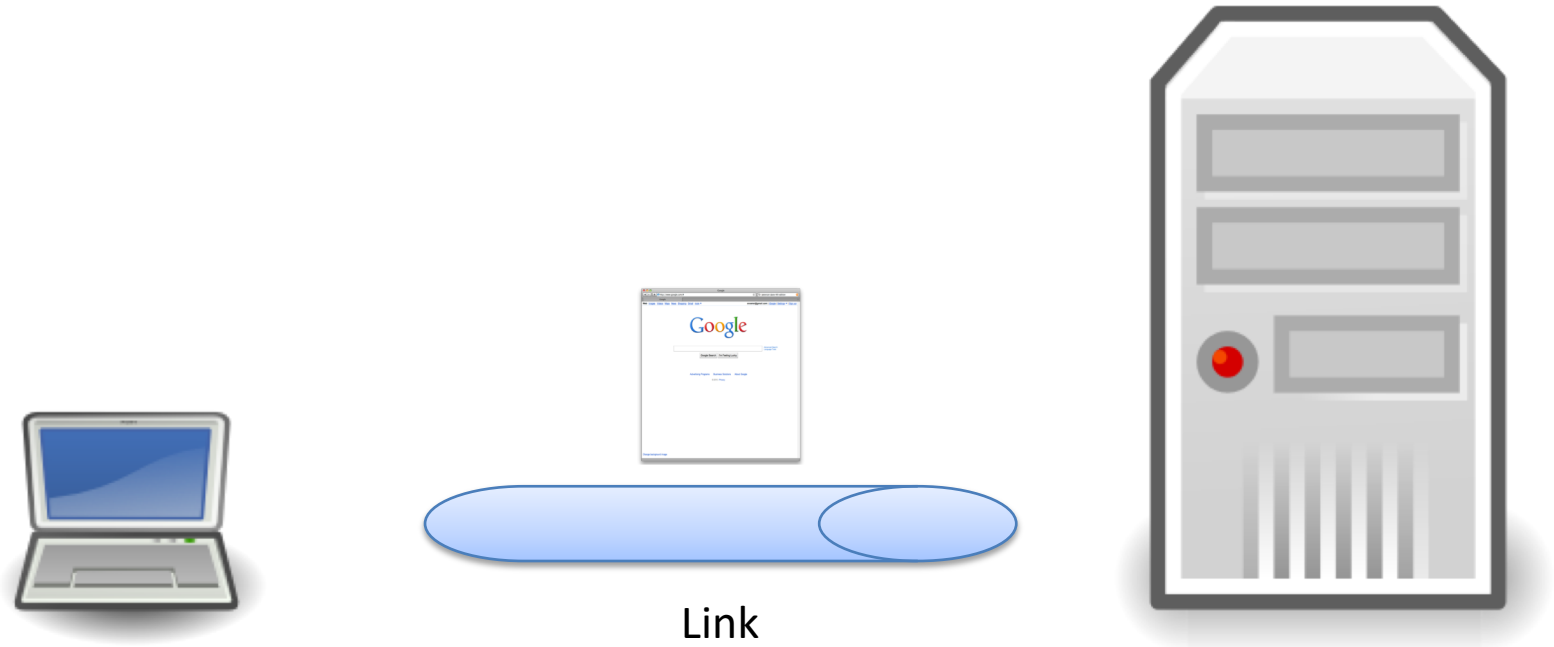
What is the goal of a network?

- Allow devices communicate with one another and coordinate their actions to work together.

- Piece of cake, right?

A "Simple" Task

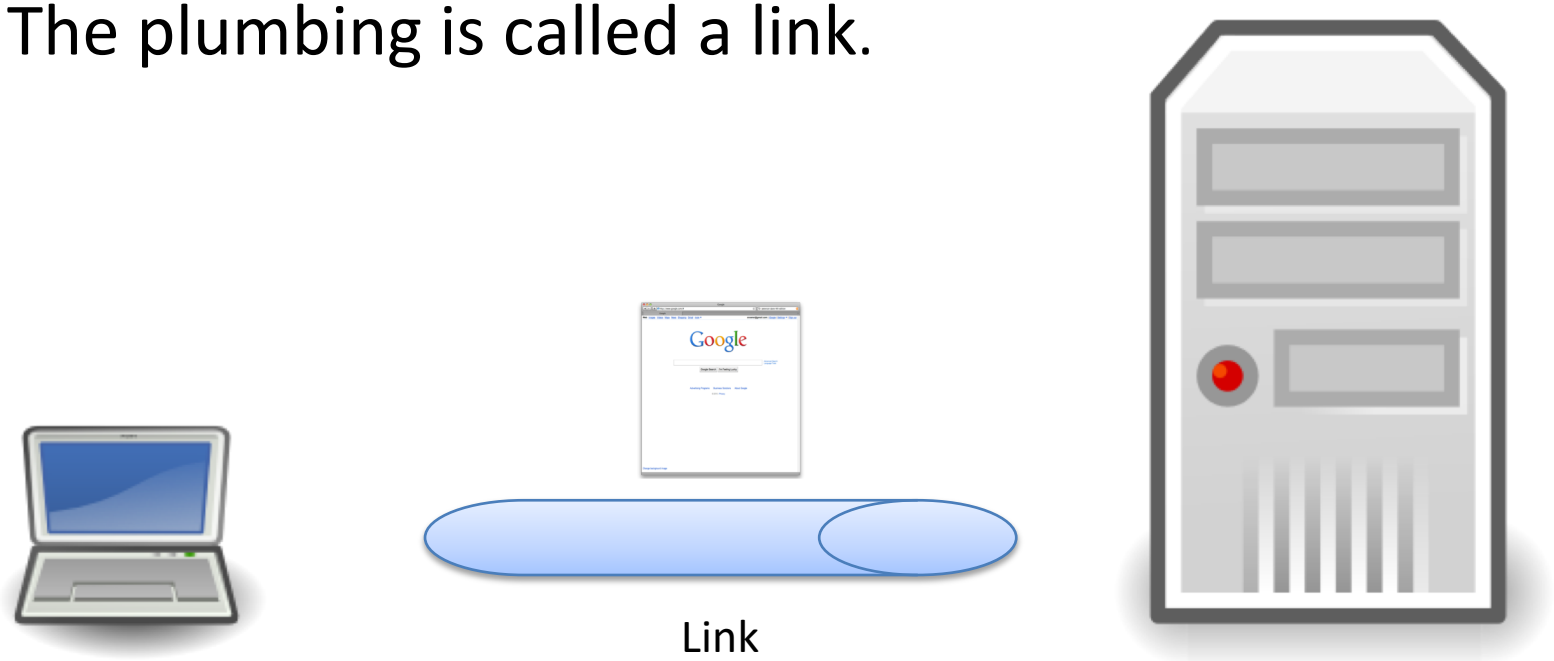
Send information from one computer to another



A "Simple" Task

Send information from one computer to another

- hosts: endpoints of a network
- The plumbing is called a link.

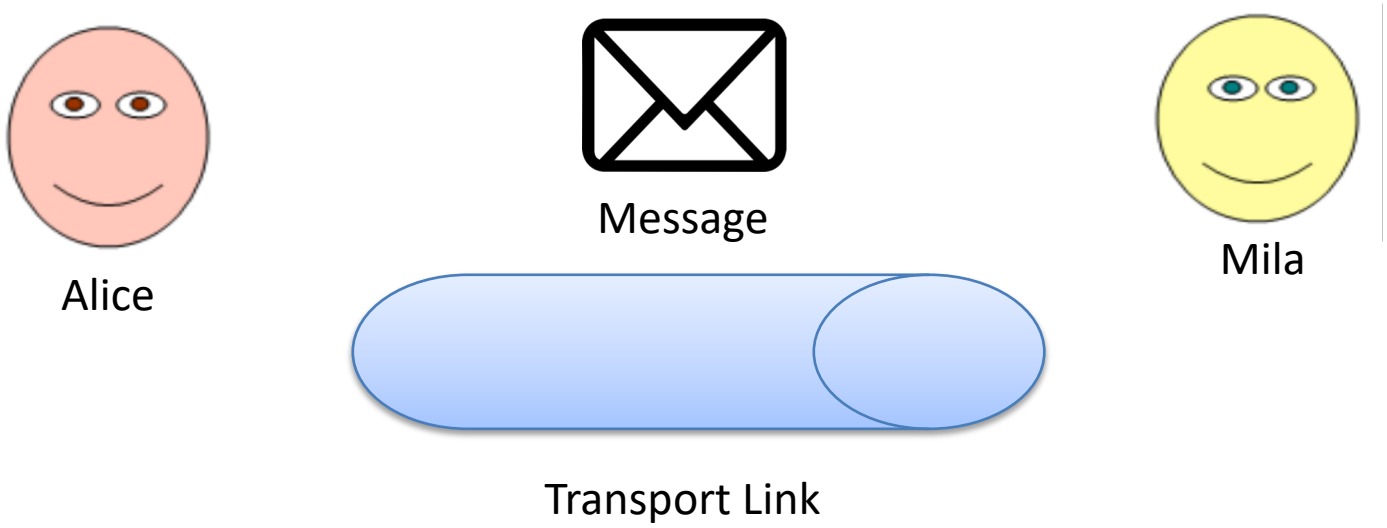


A "Simple" Task: Sending a message from host to destination

But first... let's try the postal system, something we are all (still!) familiar with and address a couple of key challenges..

A "Simple" analogous task: Post-it Note

Alice and Mila are Swatties starting out their semester and are roommates. Alice wants to give Mila a reminder to get milk.



A "Simple" analogous task: Post-it Note

Alice and Mila are roommates, Alice wants to give Mila a reminder to get milk. Figure out some key tasks:

1. **Structure of the message:**
    - Construct the message that Alice posts to Mila.
2. **Organizing a drop-off point.**
    - Who chooses the drop-off point?
3. **Write a protocol to write a note /post—it to your housemate**

A "Simple" analogous task: Post-it Note

Alice and Mila are roommates, Alice wants to give Mila a reminder to get milk.

1. **Structure of the message: (Alice to Mila)**

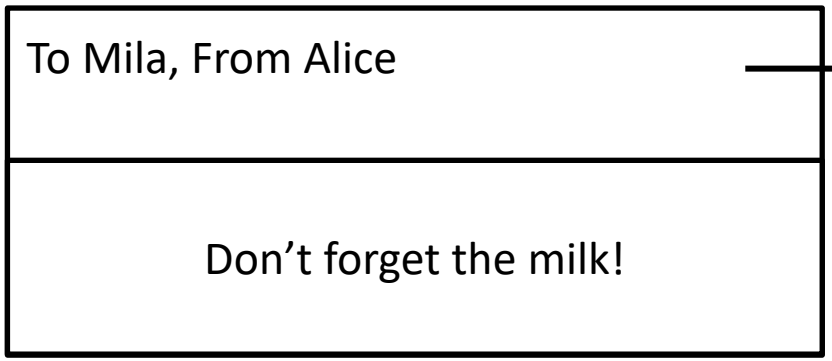
To Mila, From Alice
Don't forget the milk!

Irrespective of the source and destination, the format of the message stays the same.

A "Simple" analogous task: Post-it Note

Alice and Mila are roommates, Alice wants to give Mila a reminder to get milk.

1. **<u>Structure of the message: (Alice to Mila)</u>**



Header: contains sender/receiver information.

- metadata about the message
- what other metadata might you add?

<u>Irrespective of the source and destination, the format of the message stays the same.</u>

A "Simple" analogous task: Post-it Note

Alice and Mila are roommates, Alice wants to give Mila a reminder to get milk.

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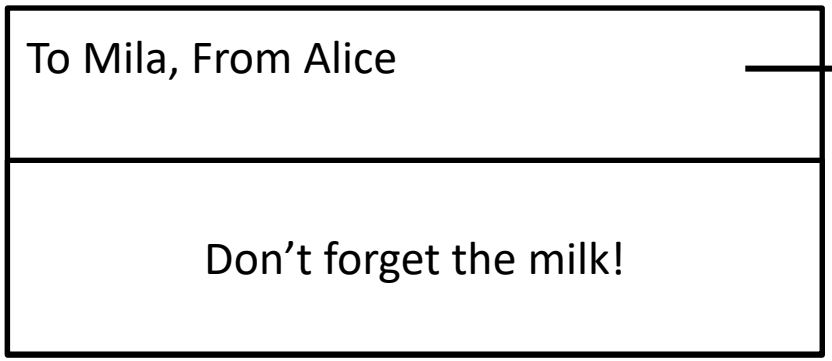
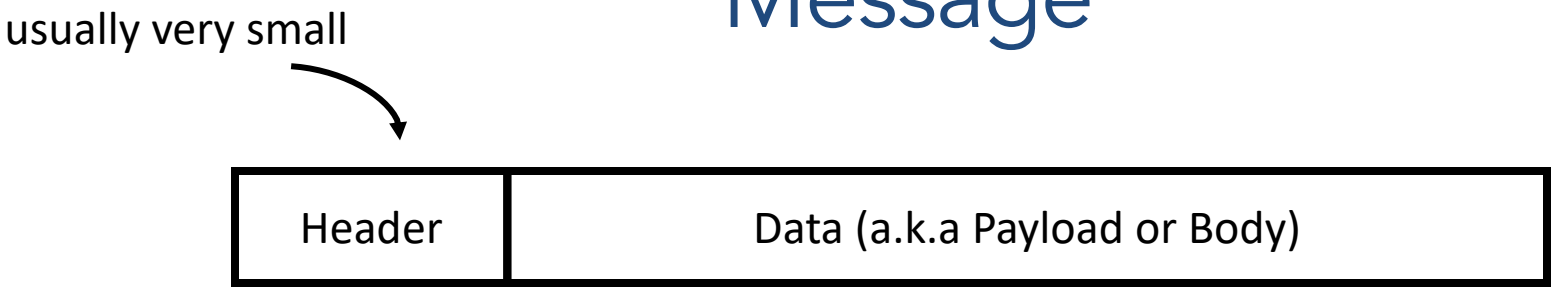


Header: contains sender/receiver information + additional state

- timestamp
- urgent! (priority)
- ordering of messages (1 of 10..)
- error control..

Irrespective of the source and destination, the format of the message stays the same.

Message



- Message: Header + Data
- Data: what sender wants the receiver to know
- Header: information to support protocol
  - Source and destination addresses
  - State of protocol operation
  - Error control (to check integrity of received data)

A "Simple" analogous task: Post-it Note

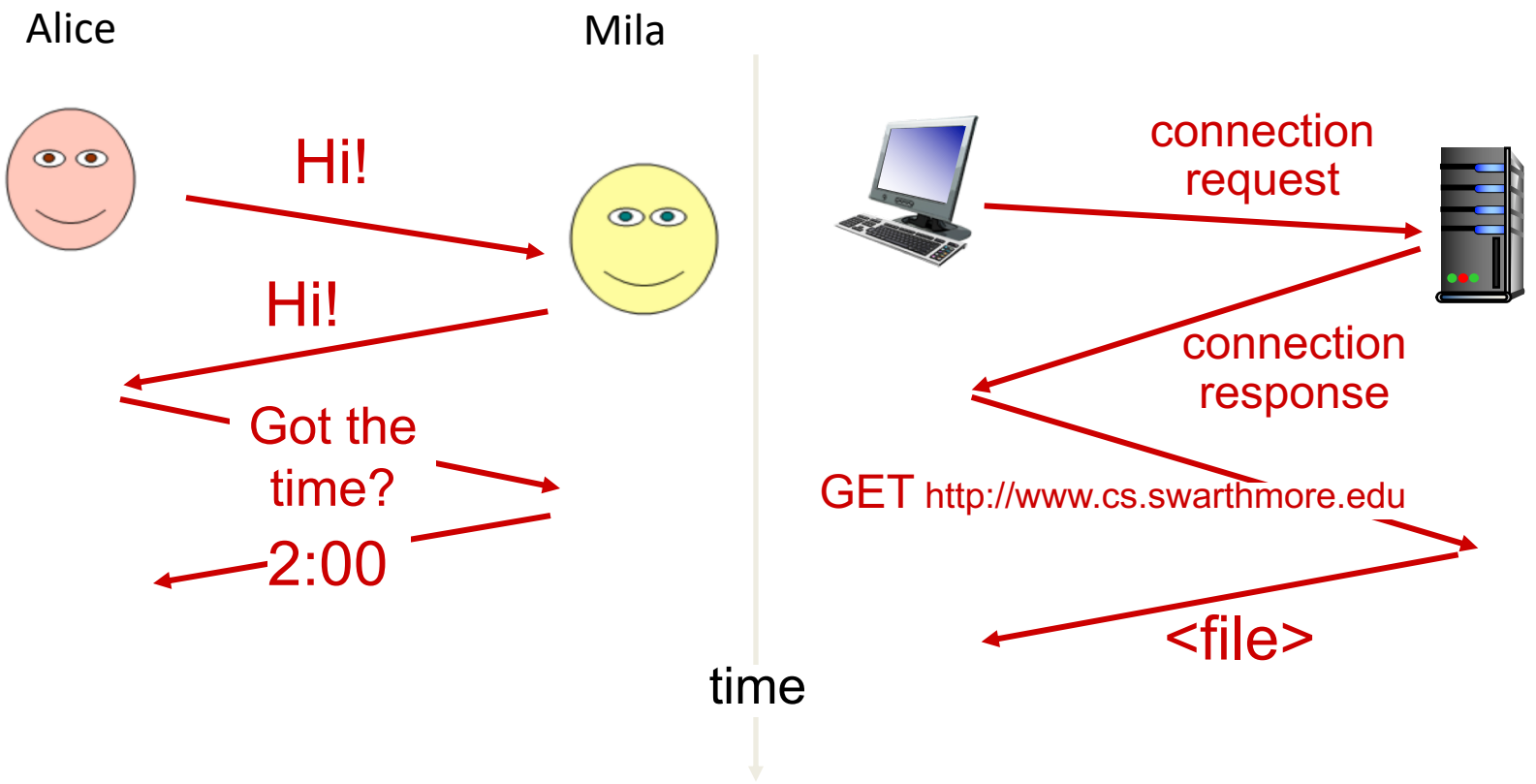
Alice and Mila are roommates, Alice wants to give Mila a reminder to get milk.

2. **Organizing a drop-off point.**
    - Who decides?
    - Generally by mutual consensus – previously agreed upon location.

Everyone agrees to place messages on refrigerator to relay messages to housemates

What is a protocol?

Protocol: message format + transfer procedure



Human Protocol

Network Protocols (defined in RFCs)

What is a protocol?

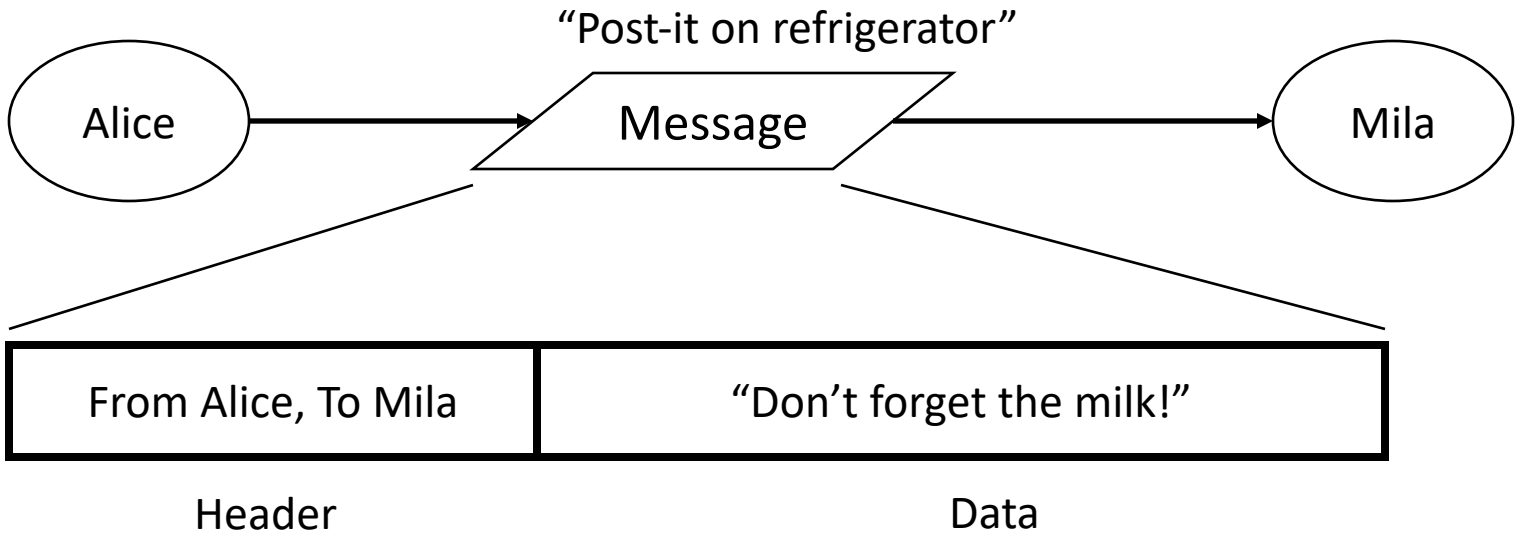
Goal: get message from sender to receiver

Protocol: message format + transfer procedure

- Expectations of operation
  - first you do x, then I do y, then you do z, ...

- Multiparty! so no central control
  - sender and receiver are separate processes

A "Simple" analogous task: Post-it Note



Write a protocol to write a note /post—it to your housemate

Protocol: message format + transfer procedure

- Message format: (from, to), message contents
- Transfer procedure: post on refrigerator

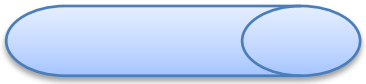
A "Simple" analogous task: Postal Mail

Alice moves to Chicago and Mila to Seattle for summer internships. Alice would like to send Mila a birthday card.

Chicago

Alice

Message



Transport Link

Mila

Seattle

A "Simple" analogous task: Postal Mail

Alice would like to send Mila a birthday card.

1. **Construct the message and header. Have the header and message portions changed from the previous scenario?**
2. **List the message format and transfer procedure of the "mail sending protocol" that Alice uses.**
   - Who chooses the drop-off point?
   - Is this the only protocol in use?
3. **Message transportation and delivery**
   - Whose job is it to:
     - choose the carrier?
     - plan the route?
     - deliver the message?
     - ensure the message is not lost?

A "Simple" analogous task: Postal Mail

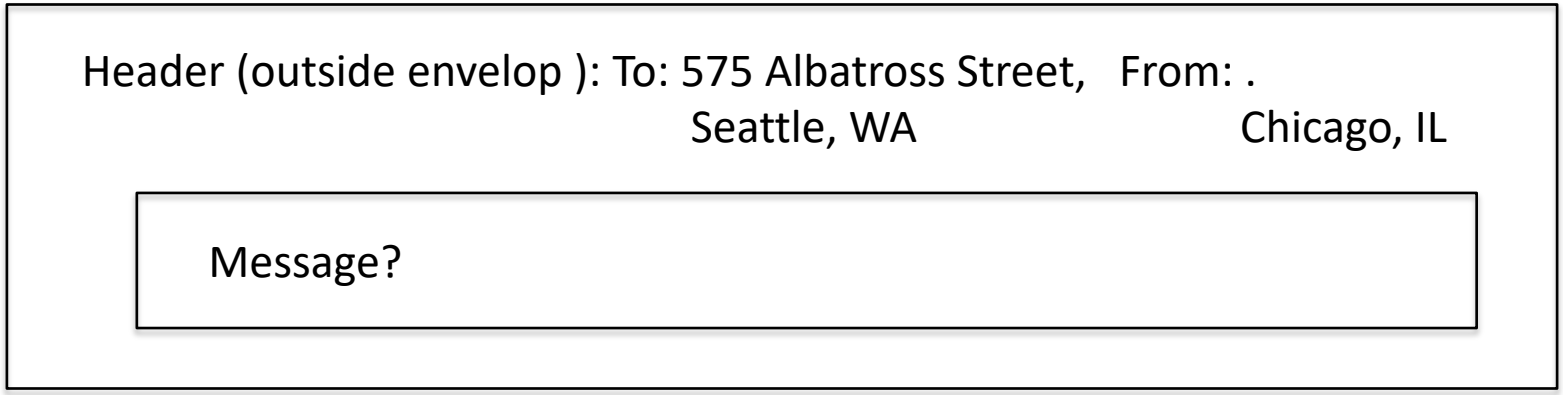
Alice would like to send Mila a birthday card.

1. **<u>Construct the message and the header. Have the header and message portions changed from the previous scenario?</u>**

A "Simple" analogous task: Postal Mail

Alice would like to send Mila a birthday card.

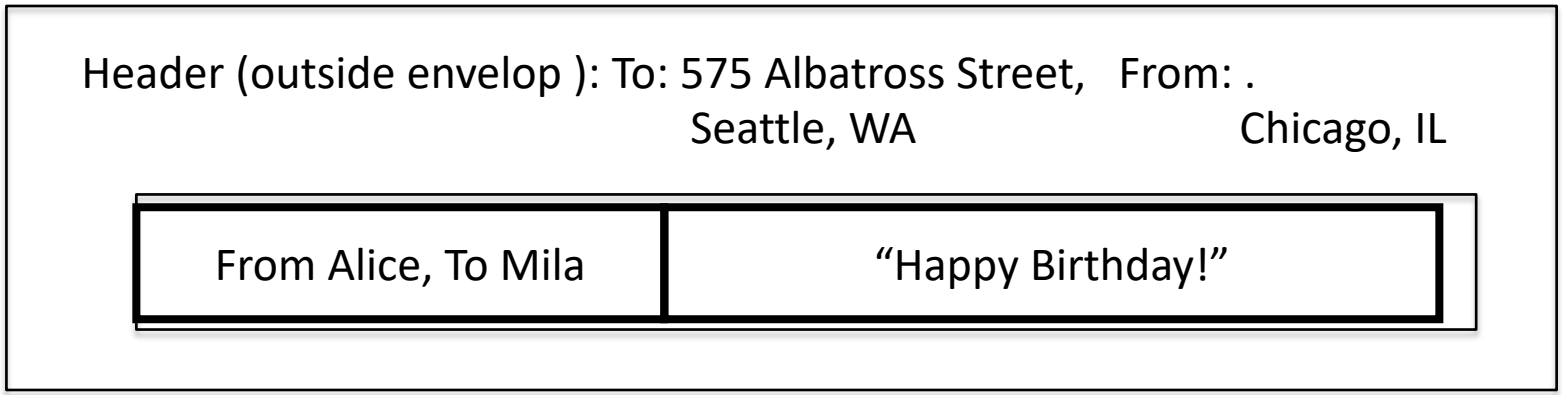
Header portion



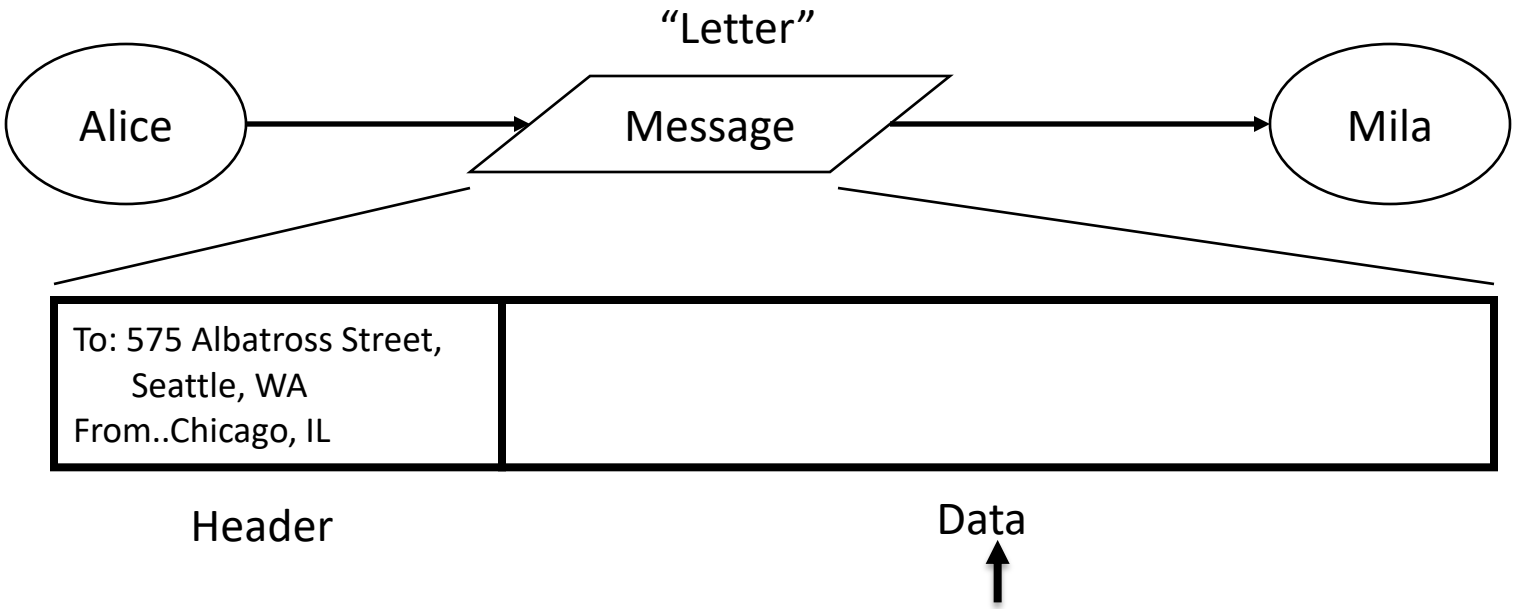
A "Simple" analogous task: Postal Mail

Alice would like to send Mila a birthday card.

Message portion

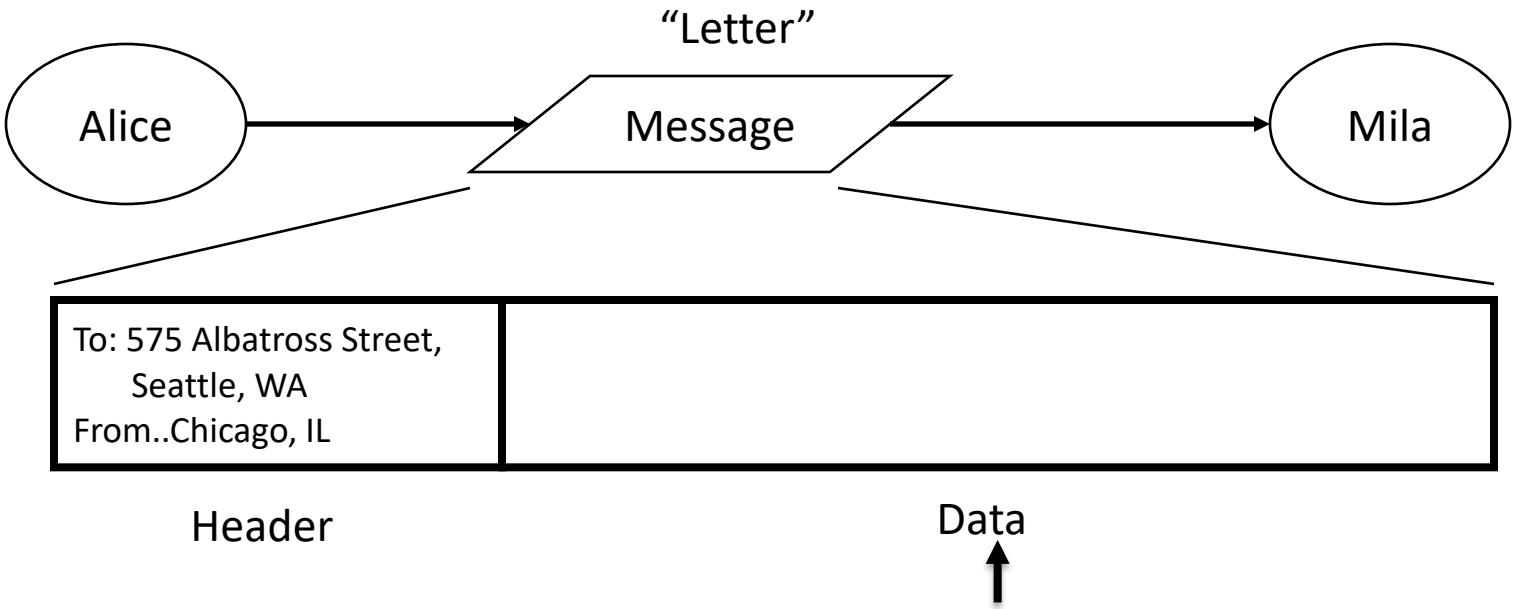


A "Simple" analogous task: Postal Mail



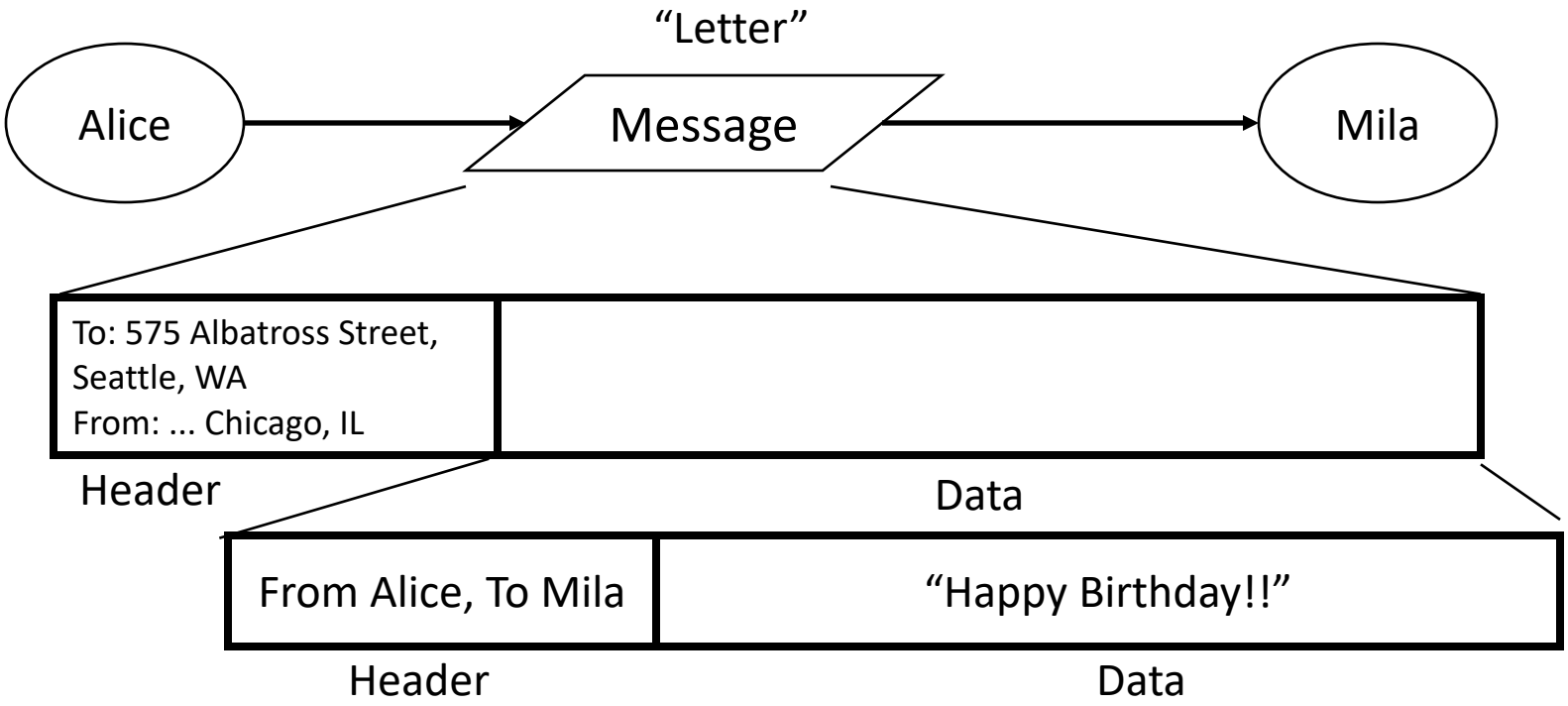
The post office does NOT care about what's in here, and shouldn't be looking at it…

A "Simple" analogous task: Postal Mail



- **Mail Sending Protocol**
  - Message format: (from, to), message contents
  - Transfer procedure: post mail in mailbox (agreed upon convention)

A "Simple" analogous task: Postal Mail: other protocols in use?



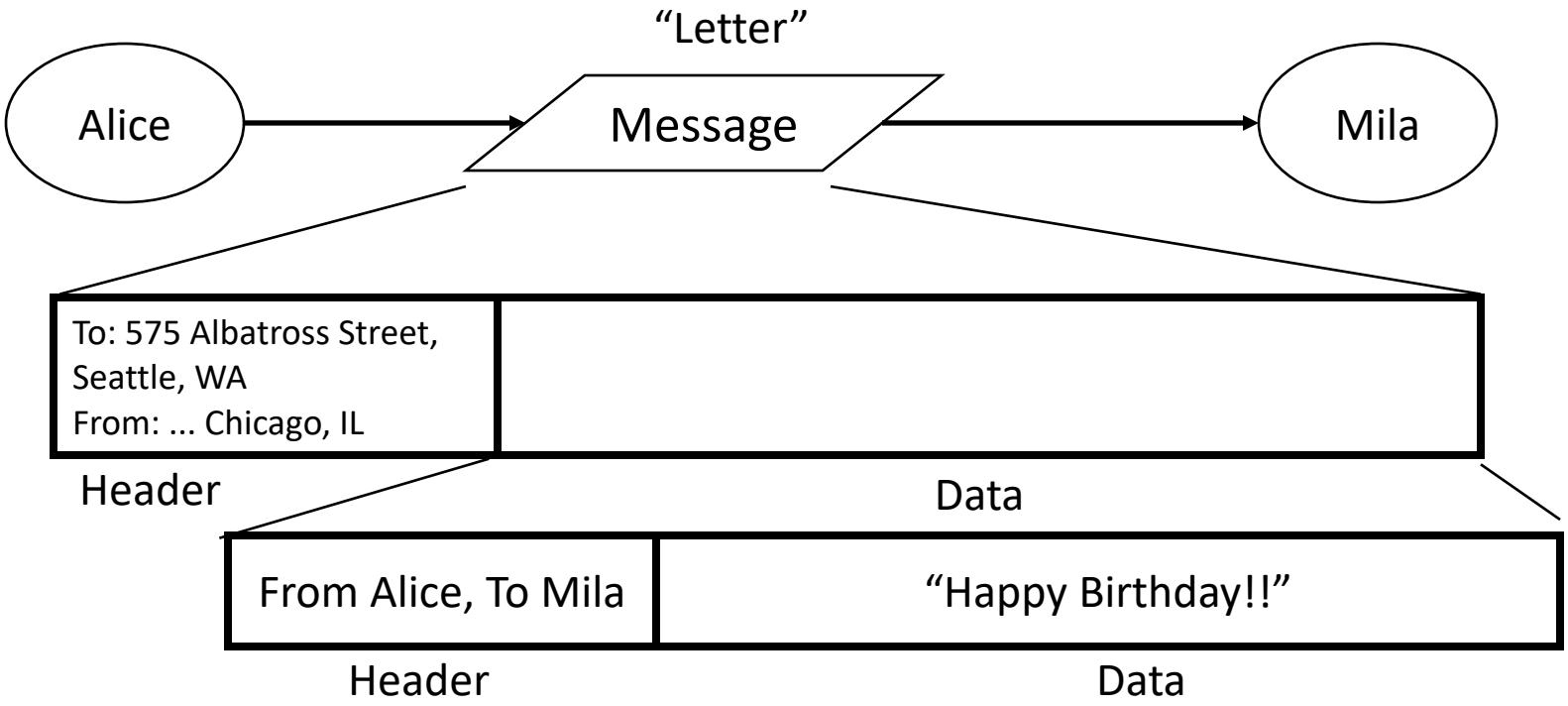
Mail Protocol

- Message format: (from, to), message contents
- Transfer procedure: post mail in mailbox (agreed upon convention)

Card Protocol (within the mail protocol!)

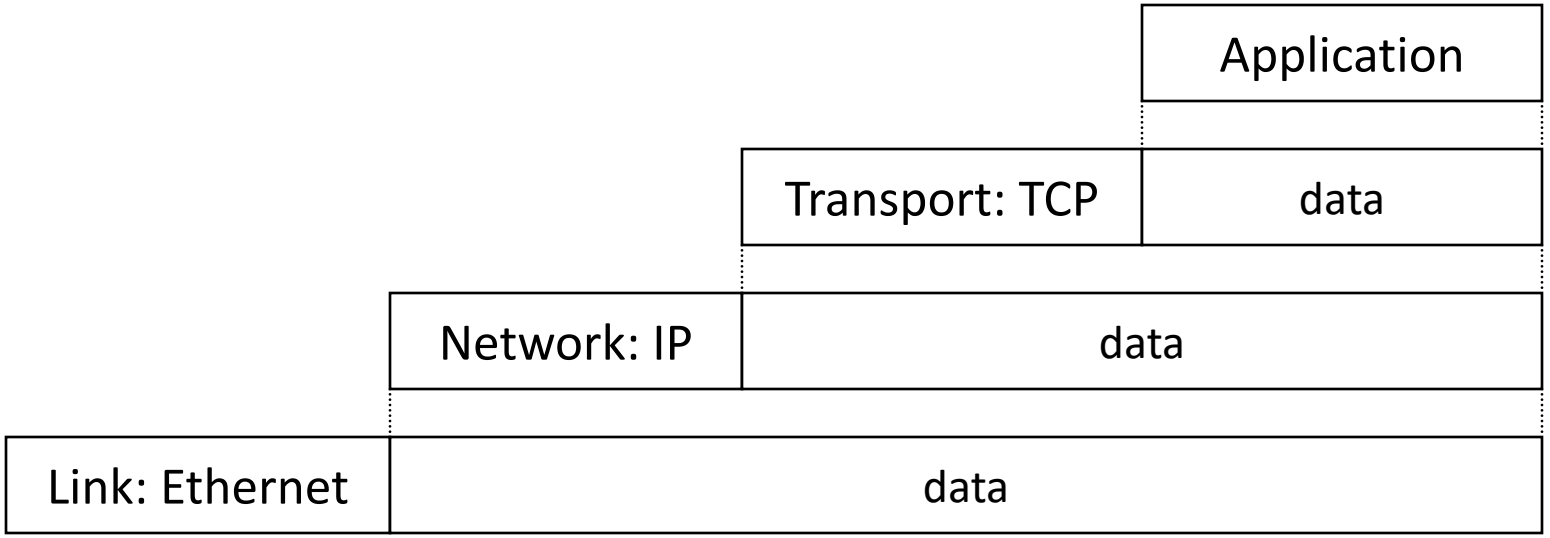
- Message format: (from, to), message contents

Message Encapsulation



- Card protocol: (message + header) treated as payload
- Put it in another protocol: append an additional header

Message Encapsulation



- Higher layer within lower layer
- Each layer has different concerns, provides abstract services to those above

A "Simple" analogous task: Postal Mail

- **Message transportation and delivery**
- Who's job is it to:
  1. provide the sender and receiver addresses?
  2. choose the carrier?
  3. plan the route?
  4. deliver the message?
  5. ensure the message is not lost?

A "Simple" analogous task: Postal Mail

- **Message transportation and delivery**

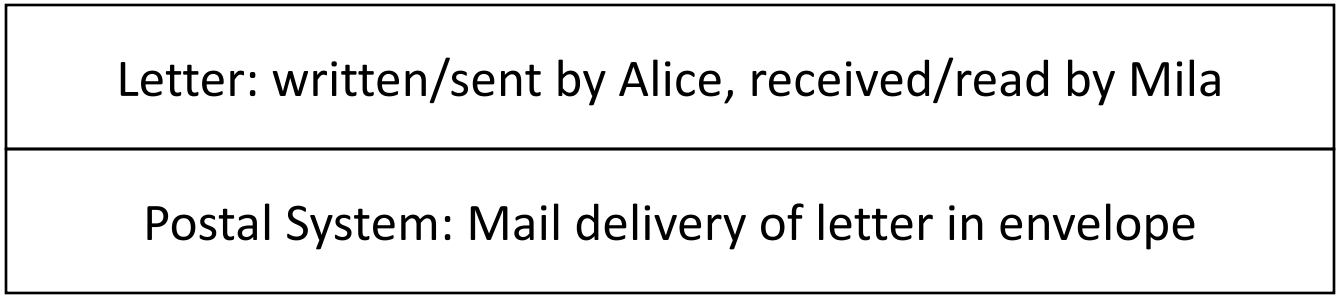
- Who's job is it to: Alice decides as the "end host"(1, 2)

1. provide the sender and receiver addresses?
2. choose the carrier?
3. plan the route?
4. transport vehicles?
5. ensure the message is not lost? (reliability)

Postal Department decides as the service that provides message transfer (3, 4)

Reliability? Open question – stay tuned!

Layering: Separation of Functions



- Alice and Mila
  - Don't have to know about delivery
  - However, aid postal system by providing addresses
- Postal System
  - Only has to know addresses and how to deliver
  - Doesn't care about "data": Alice, Mila, letter

Abstraction!

- Hides the complex details of a process
- Use abstract representation of relevant properties make reasoning simpler
- Ex: Alice and Mila knowledge of postal system:
  - Letters with addresses go in, come out other side

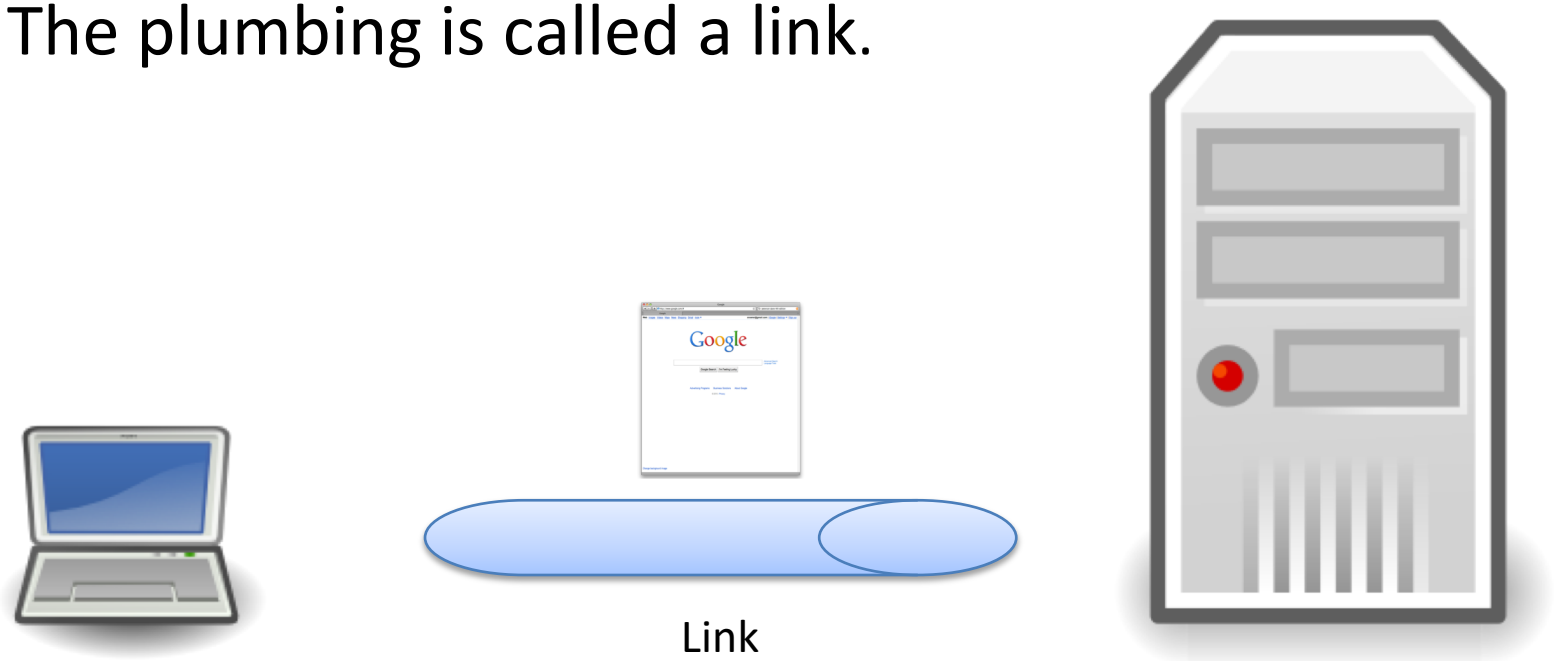
A "Simple" analogous task: Postal Mail

- Many more considerations..
  - Who decides the the sender and receiver addresses? Does someone maintain a mapping peoples' names to addresses?
  - Can Mila always be guaranteed of this delivery date? What factors influence delivery ?
  - What if the mail gets lost – who's responsibility is it? Alice, Mila or someone else?
  - What about security? privacy?

A "Simple" Task

Send information from one computer to another

- hosts: endpoints of a network
- The plumbing is called a link.



Next Class

- Layering & division of responsibilities
- OSI Model
- End-to-end argument
- HTTP! An Application Layer Protocol

TODO List

- Reading: Protocols
  - Sections 1.1, 1.5
- Sign up on Piazza!
- Register your clicker!
- Please let me know:
  - Your preferred name/pronouns, if different than roster information
  - Academic accommodations