

# Networking

**Melissa Winstanley**  
**[mwinst@cs.washington.edu](mailto:mwinst@cs.washington.edu)**

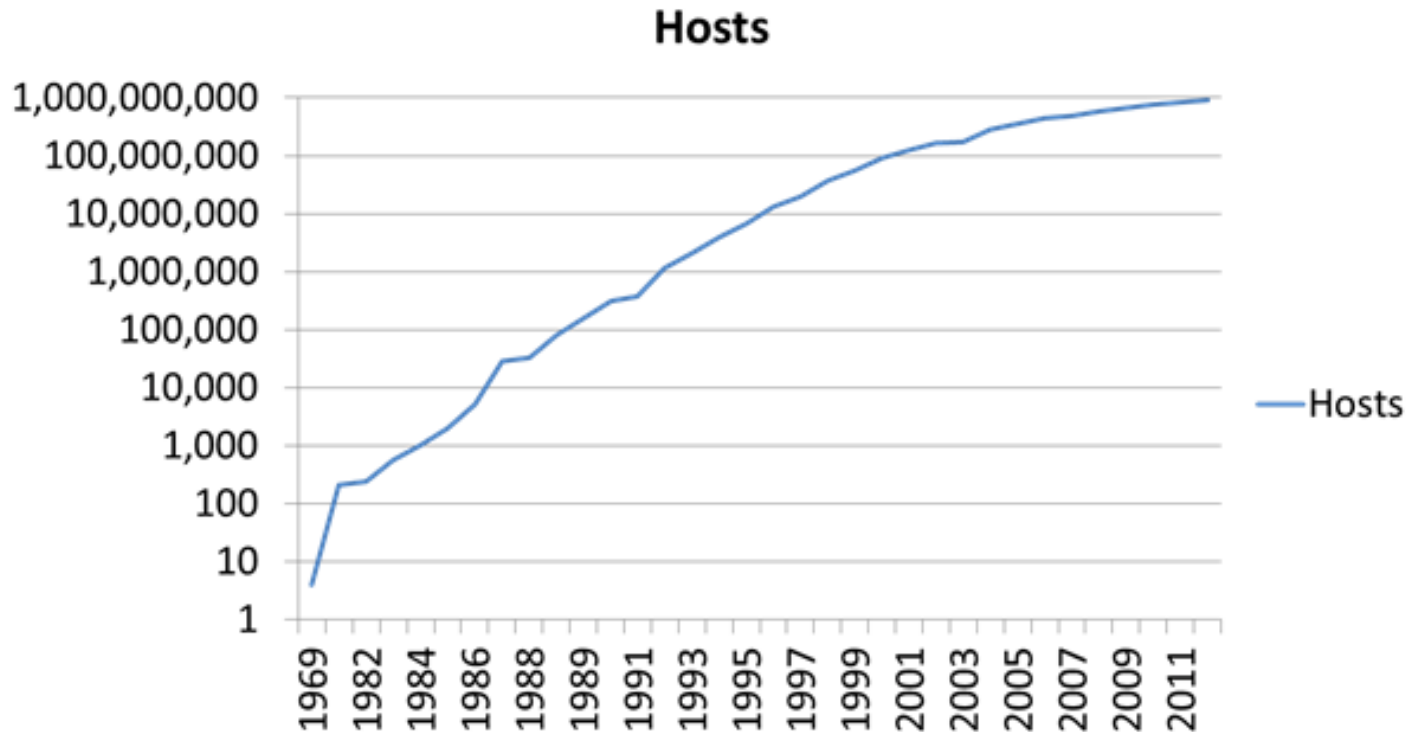
# What is a computer network?

- "A collection of autonomous computers interconnected by a single technology"
  - Can exchange information
  - Many different technologies
  - Many sizes
  - More than just the Internet!

# What do you do using networks?

- Browse the internet
- Watch TV
- Use your cell phone
- Draw money from an ATM
- Play the latest MMORPG
- Check Facebook
- Ride the bus with your UPass

# The Internet



Why has it been so successful?

# One part of the answer

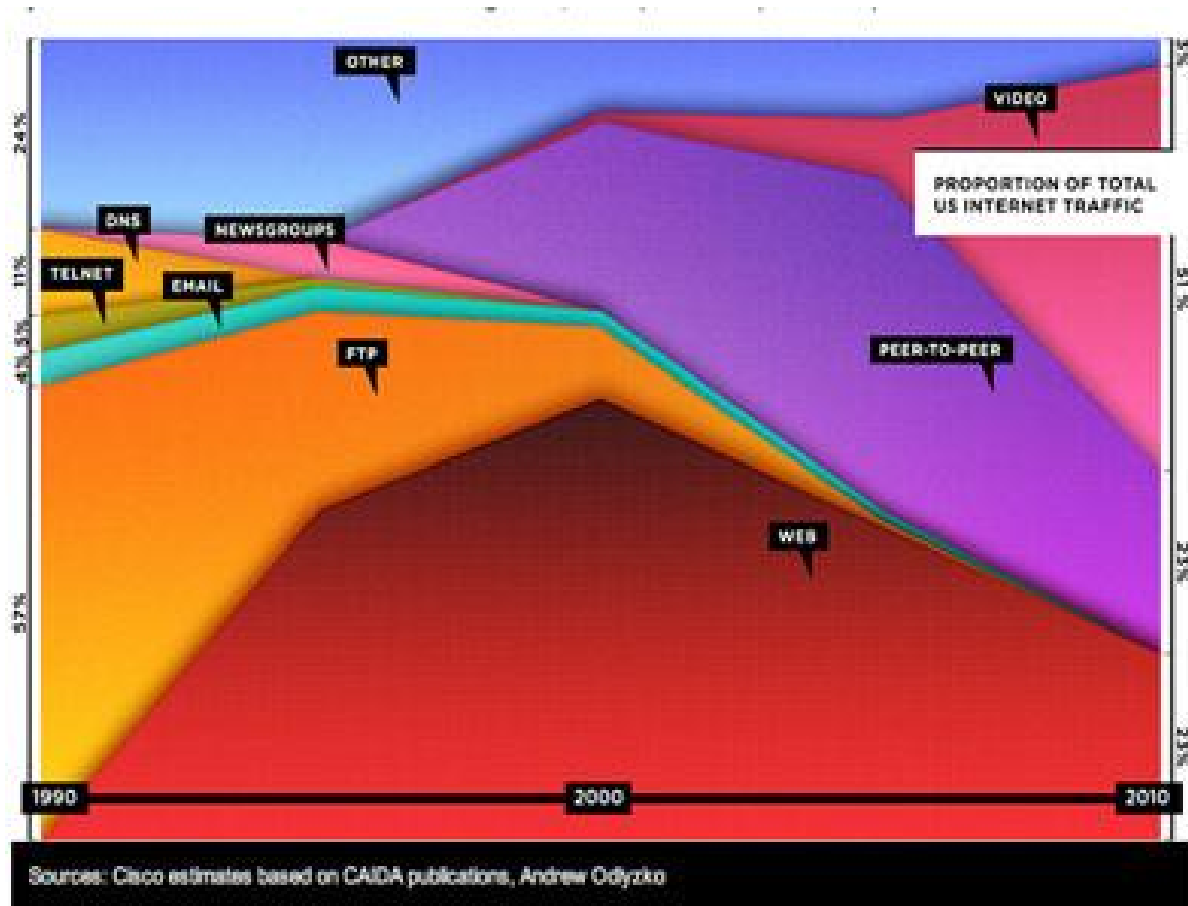
- The "End to End Argument" (Reed, Saltzer, Clark, 1984):
  - *Functionality should be implemented at a lower layer only if it can be correctly and completely implemented.*
- Tends to push functions to the endpoints, which makes the Internet transparent and extensible
- Network makes almost no guarantees
  - We'll try to get your data to the destination, eventually. Maybe
  - No performance guarantee
  - No reliability guarantee

# What does it mean?

- Many problems with the Internet must be addressed when writing applications
  - Ex. reliability
- Techniques of the Internet are helpful
- Design decisions made by others can help us build better applications

# Another trend

Cisco's estimate  
by 2014:  
91% video



# Goals





# What do we need to think about?

- Encapsulation
- Reliability
- Physical limits
- Importance of engineering issues
- Weakening of correctness
- Dealing with a changing world
- Improving speed and efficiency
- Error handling

# Requirements

- A standard protocol
- Detect errors
- Be able to correct errors in some way
- Recognize destinations (routing)
- Detect malicious users

# RFID

**A simple example**

# Why RFID?

- Networks are really complicated
- Start with a fairly simple system
  - Introduce important concepts
  - Understand the basics
- Then talk about differences with the Internet

# What is RFID?

- Automatic identification system
- Each object has a tag
  - Passive wireless device
- Readers send out signals to tags
  - Tags get power from the reader
- Does not require line-of-sight
  - But a few inches to meters









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## A Guide to Intelligent Travel

April 11, 2011, 2:36 PM |  11 Comments

### Gee, How Did That Towel End Up in My Suitcase?

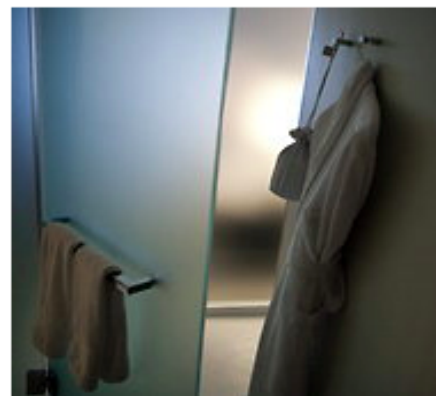
By SARA J. WELCH

Hotel guests may want to think twice now before walking off with that bathrobe. Linen Technology Tracking, a company in Miami, has patented a washable RFID chip that can be sewn into towels, robes and bed sheets, allowing hotels to keep track of their linens.

So far, three hotels — in Honolulu, Miami and Manhattan — are using the chip, said Linen Technology Tracking's executive vice president, William Serbin. He said the hotels did not want their names used.

Mr. Serbin added that rising cotton prices were a motivation: "A bath towel that might have cost \$5 last year could cost \$8 or \$9 now. High-end hotels want to watch those assets."

The Honolulu property, which introduced the technology last summer, has reduced theft of its pool towels from 4,000 a month to just 750, saving more than \$16,000 a month, Mr. Serbin said.



Brendan Smialowski for The New York Times



## Getting Smart About Personal Technology

September 25, 2012, 5:57 PM | [22 Comments](#)

### Radio-Tagged Socks for the Obsessive

By ROY FURCHGOTT

How do you know when you have slipped from detail-oriented, past anal-retentive, all the way to obsessive-compulsive?

You might be an extreme case if you can't wait to get your hands on [Plus+](#) socks from [Blacksocks](#), a Swiss company that attaches a radio ID tag to its socks so you always put the correct pair together. Apparently this is something of a problem for people who wear nothing but identical black socks.



“The thing is, when you buy them, first they are exactly the same,” said Samy Liechti, founder of Blacksocks, in a call from Zurich. “But what people do is they take out the socks in the drawer at the front.” As some socks get washed more than others, they start to fade, and thus customers no longer have

# How it works

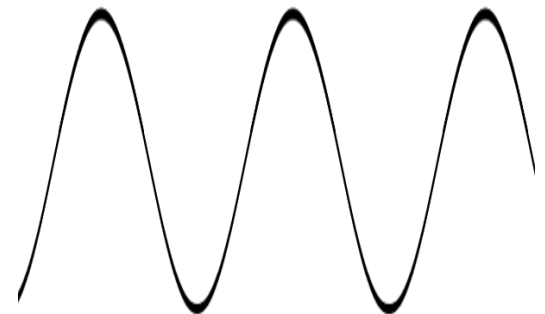
**RFID: physical layer**

# CONCEPT: physical layer

- Network problem: transmit 0's and 1's
- Medium of transport: waves



- How do we do it?
  - Modulation - frequency, for example

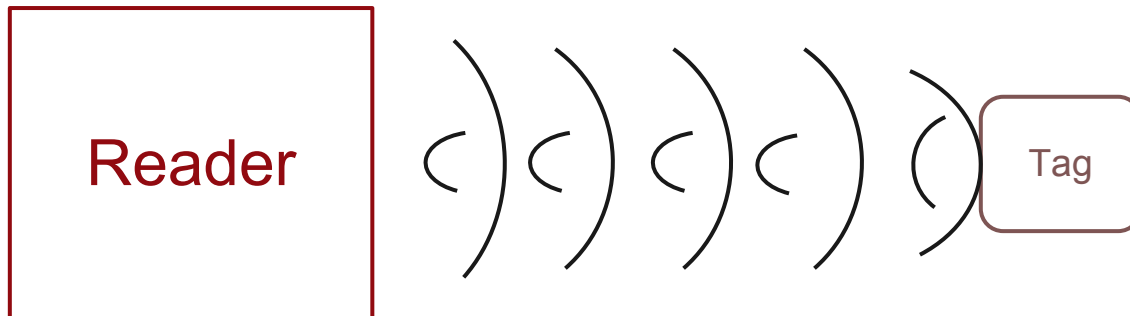


# CONCEPT: transport types

- Copper wire (old school)
- Fiberoptic cable
- Wireless technologies
  - Satellites
  - Radio waves
  - Infrared
- And more being developed all the time

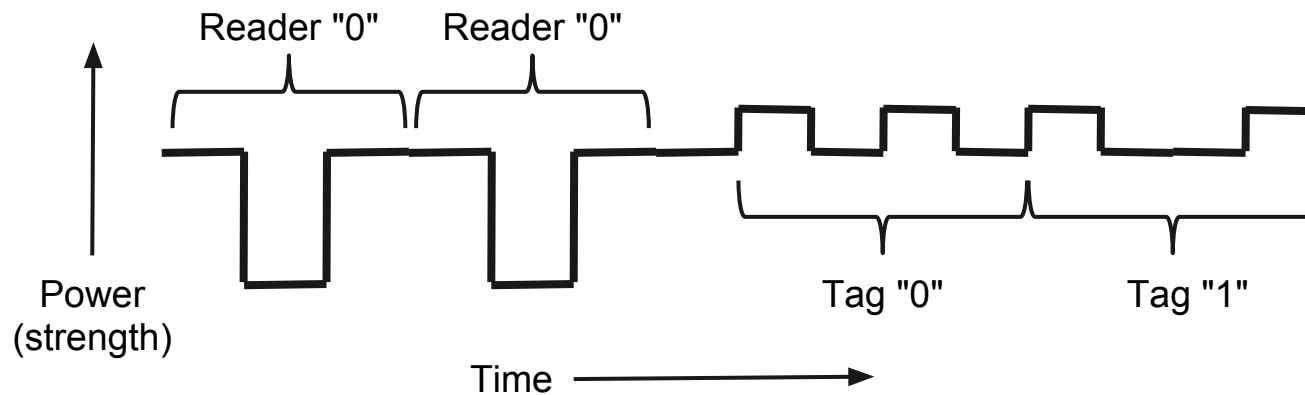
# RFID

- Composed of 2 halves
  - RFID reader
  - RFID tags
- Reader is powered - can send radio signals
- Tag has no power
  - So how does it communicate?



# RFID Backscatter

- Reader modulates, tag selectively reflects the signal





**Next layer: basic software**

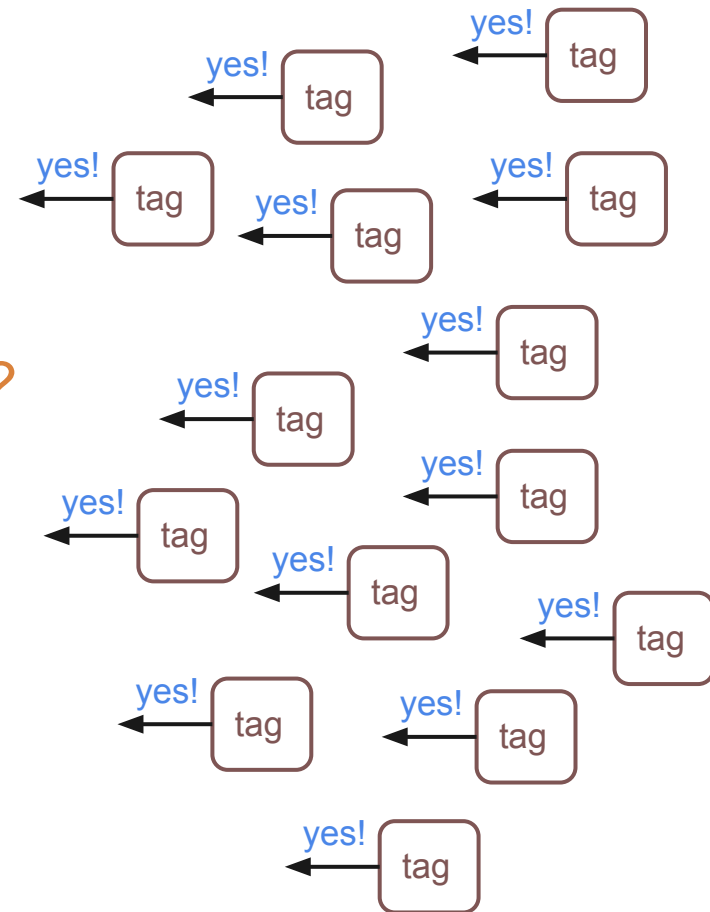
# Another problem



# Another problem



*Anyone there?*



# CONCEPT: collisions

- Problem: machines sending at the same time
- If two tags talk at the same time, their waves collide
  - Neither can be heard correctly
- How do we fix this problem?
  - Add **REDUNDANCY**
  - Ex. send more data, so that we can check that the message is correct

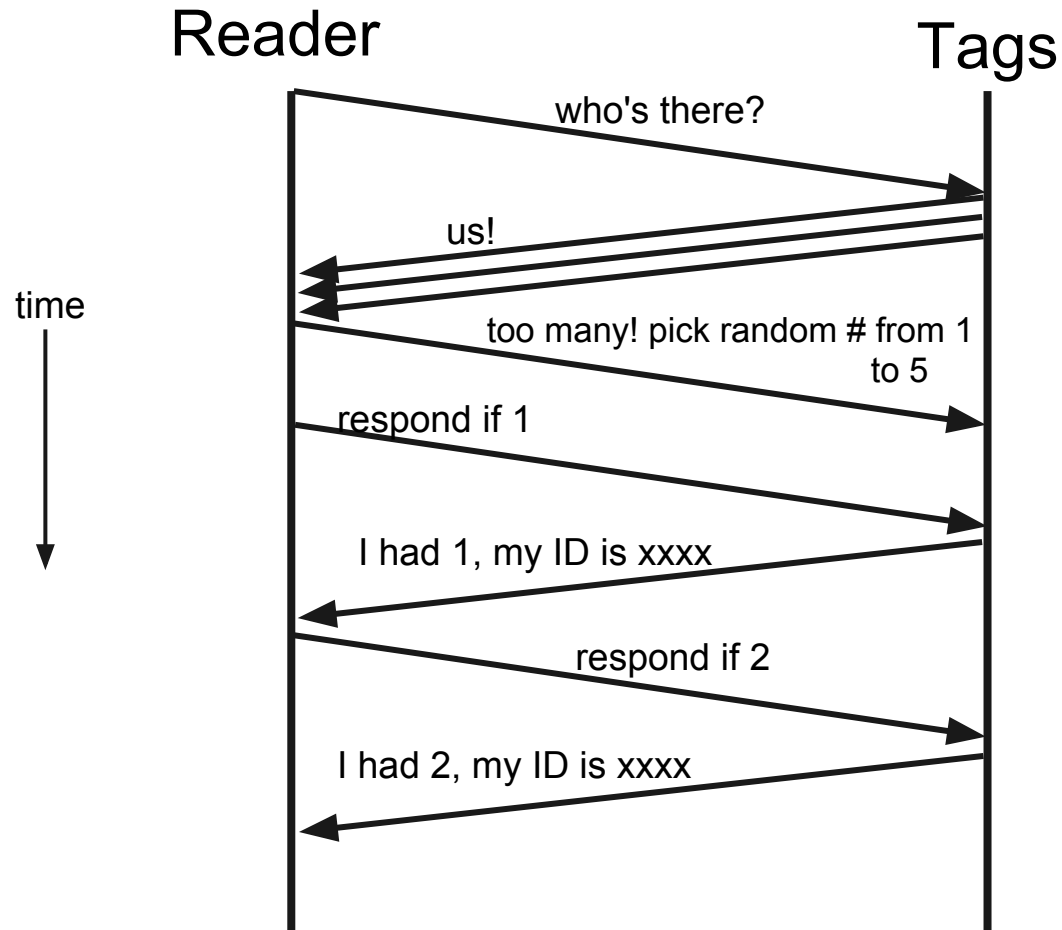
# Limitations of physics

- Tags have almost no memory - just an ID
  - Analogous to human memory
- They have almost no compute power
  - Hardware implementation of simple state machines
- They have almost no transmit power
  - Low bandwidth, high error rate
- Result: communication largely under control of the reader

# So now what?

- We want to find the unique ID for each tag
- But they have to respond one at a time
- Tags are completely passive
  
- Let's simulate

# One strategy



# But there's still a problem!

- What if two tags pick the same random number?
  - They'll collide again
- What can we do?
  
- Have everyone pick a new random number in a bigger range
  - From 1 to 10
  - If there are lots of tags we can deal with it
  - If there are few tags, we don't waste time



# You just learned real stuff!

- First idea is called a *"slotted Aloha network"*
- Second idea is called *"binary exponential backoff"*
- But names really aren't important
  - How to send signals?
  - How to deal with collisions?

**What about large-scale systems?**

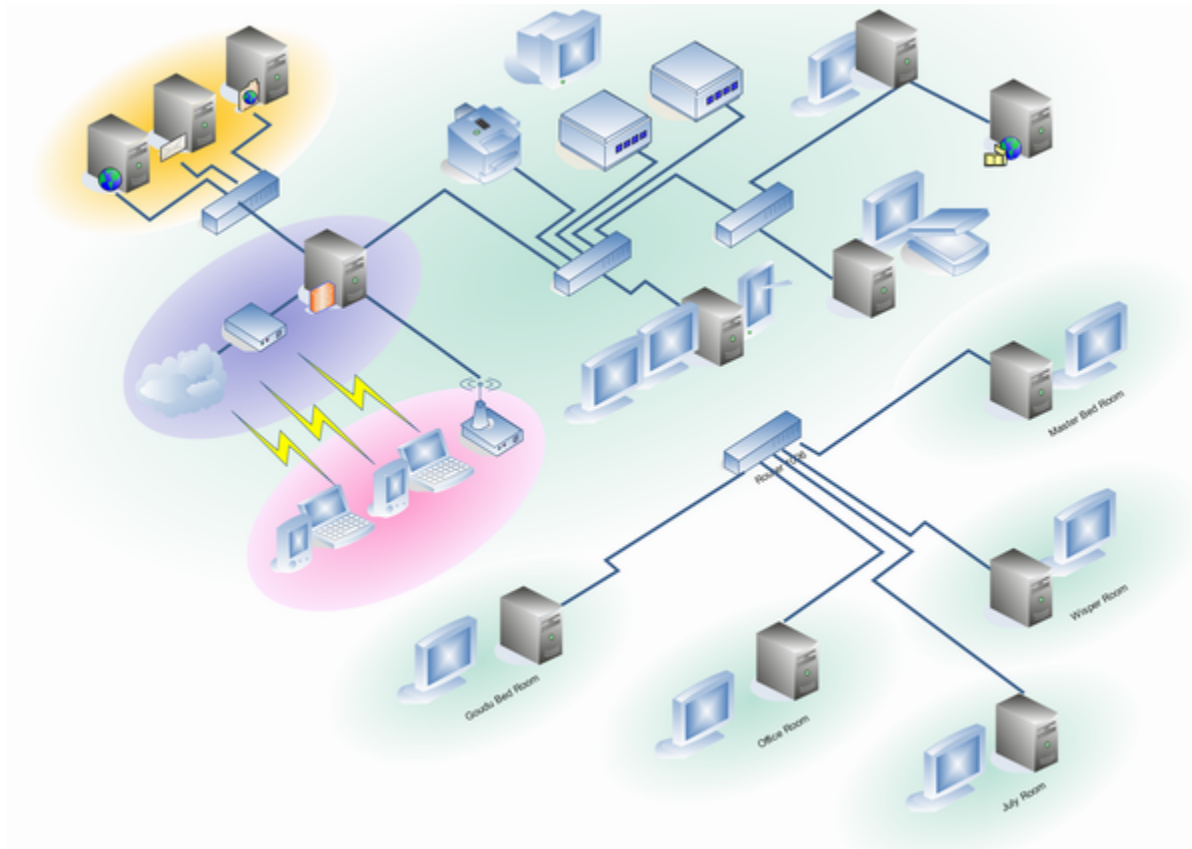
# Differences

- Many more participants
  - "Servers" and "clients"
  - Millions and millions of hosts
  - Interconnected in far more ways
- Different types of protocols
  - Ethernet (wired)
  - WiFi
  - Satellite
- Increasing distance
  - Communication all over the world

# Generalization of RFID

- "Readers" and "tags" become "hosts"
- The "messages" between tag and reader are "packets"
  - Fundamental unit of communication
    - Above the physical layer
  - Transmit information between hosts
- One message may be split up into many packets and reassembled at the recipient

# Connected hosts



# Sending a message

- I want to access Facebook.
  - I go to [www.facebook.com](http://www.facebook.com)
  - My browser sends a *request* (packet) to Facebook
- The Internet is a big place
- How do we say we want to talk to "Facebook"?

# IP Addresses

- Each computer has an *IP address*
  - Like a phone number
- Each IP address is *unique*
- Ex. "69.63.176.13"
  
- IP addresses are hard to remember
  - So for some destinations, we give them names
  - Ex. "facebook.com"

# From IP address to destination

- We know we want to contact 69.63.176.13
- No direct link from here to there
- We need help!
  
- A *router* connects your computer to the Internet
- Routers connect to each other
  
- RECURSION!
  - Let the router figure out how to send it

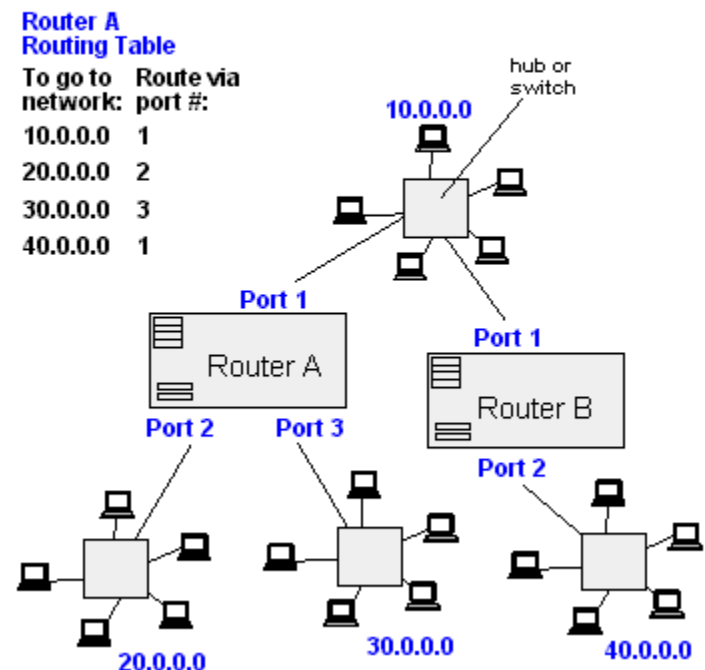


# Routing

- Routers are connected to each other.
- Routers talk among themselves to decide where to send a packet

From Computer Desktop Encyclopedia  
© 1998 The Computer Language Co. Inc.

- Many different algorithms



# Reception

- Facebook computer 69.63.176.13 is always listening
  - This is a "server"
- Receives your packet
- Figures out what to send
  - In this case, the html for "facebook.com"
- Divides the message into little pieces (packets)
- Sends back to you
  - What does it need to know to do this?

**So how does the router  
know where to send it?**