**Top-down approach**: Going from Application Layer down to Physical Wires etc.

* **Application Layer:** Applications used to build the services.
  + i.e. Email client to enable email exchange between two people.
* **Transport Layer**, **Network Layer, Physical Layer** (mostly self-study)

To learn the fundamentals of computer networks:

1. What **hard problems** must they solve?
2. What **design strategies** have been proven valuable?
3. How do we evaluate **network performance**?

+ What are **TCP/IP**, **DNS**, **HTTP, NAT, VPN’s, 802.11** how does browsing the Web work?

What is the internet?

* **Hosts or End Systems:** The millions of connected devices that run **network apps**
* **Communication Links:** fiber / copper/ radio/ satellite etc.
* **Bandwidth:** thetransmission rate / bits per second
* **Packet Switches: Routers / Switches** that forward packets / chunks of data between devices
* **Internet**: Interconnected ISP’s (Internet Service Providers = org that provides access to int services)
* **Protocols**: Control sending and receiving (transmission) of msgs. (TCP, IP, HTTP, Skype, 802.11)
* **Internet Standards**: RFC (Request for comments), IETF (Internet Engineering Task Force)

A service view of the internet

* The internet is an infrastructure that provides services to applications
  + Web / VoiP, email, games, ecommerce, social nets etc.
* Provides programming interfaces to apps
  + Hooks that allow sending / receiving app programs to connect to the internet
  + Provides service options, analogous to a postal service.

What is a protocol?

* They are basically a set of rules.
* **Protocols** **define the format, order of msgs sent and received among network entities and actions taken on msg transmission and receipt.**
* All communication activity on the internet is governed by protocols
* **TCP (Transmission Control Protocol)** is one of the most popular protocols

The network structure

* **Network Edge**: The end devices which connect to the network
  + Hosts = clients and servers. Servers are often in data centres.
* **Access Network** **/ Physical Media**: What allows you to to connect to the internet.
  + Wired, wireless communication links etc.
* **Network Core**: Interconnected routers / network of networks

Access networks

* How do we connect the End Systems to the Edge Router?
  + Residential access nets, institutional access networks (school, company), mobile access networks
* Things to keep in mind about access networks:
  + Bandwidth (bits/sec) of access network? Shared or dedicated bandwidth?
  + DSL = dedicated bandwidth. Cable = shared bandwidth.
  + Congestion if too many people are using shared network.
* Access network example #1: Home network
  + Wireless Access Point (54 Mbps), Router, Firewall, Wireless Devices, cable or DSL modem, wired ethernet etc.
* Access network example #2: Enterprise network
  + Ethernet switch, institutional mail / web servers, institutional router, institutional link to ISP.
  + 10mbps, 100mbps, 1gbps, 10gbps transmission rates.
* Wireless Access Networks
  + Shared wireless access network connects end systems to the router
  + **Wireless LANs** = within building, 802.11 (WiFi), 11 / 54 / 450 mbps transmission rate
  + **Wide-area wireless access** = provided by telco (cellular operation, 10’s kms), 1 to 10mbps, 3G / 4G: LTE

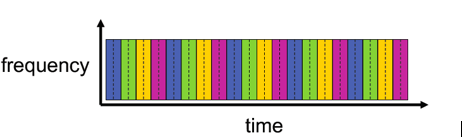
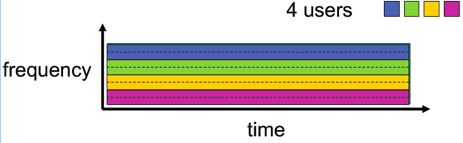
Physical Media

* **Bits**: Propagates between transmitter / receiver
* **Physical Links:** what lies between transmitter / receiver
* **Guided Media:** Copper / Fiber / **Unguided Media:** signals propagate freely i.e. radio
* **Twisted Pair:** two insulated copper wires.
* **Fiber Optic Cable**: glass fiber carrying light pulses, each pulse = 1 bit
  + Low error rate / high-speed operation 10’s-100’s gbps
* **Coaxial Cable:** two copper conductors / broadband
* **Radio**: Signal carried in electromagnetic spectrum (no physical wire)
  + Propagation environment effects: Reflection / Obstruction by objects / Interference
  + Radio link types: **Microwave (45mbps), LAN (WiFi) (1/45/450mbps), Wide-Area (~10mbps), Satellite (kbps to 45mbps)**

The Network Core is the mesh of interconnected routers / switches. Two forms of switched networks:

**1. Circuit Switching**: Used in legacy systems / traditional telephone networks

* End-to-end resources allocated / reserved for “call” between source and destination. Dedicated resources: no sharing
* If a connection is established with customer, even if customer is idle, no one else can use it (no sharing)
* Two technologies for Circuit Switching:
  + 1. **FDM (Frequency Division Multiplexing)**: Users share divided frequency / use frequency simultaneously
    2. **TDM (Time Division Multiplexing)**: Frequency is given to one user who gets to use the whole frequency / round robin to share use



* Timing in Circuit Switching: **Circuit Establishment 🡪 Transfer of Information 🡪 Circuit Tear-Down**
* Pros and cons of circuit switching?
  + PRO: Uninterrupted connection, reserved and dedicated for you.
  + PRO: Potentially faster depending on how much reserved / generally super performance
  + CON: Reserved channel even for idle connections, can’t be used by anyone. I.e. Waste of resources.

**2. Packet Switching**: Used in the internet

* Data is chopped into small chunks of formatted **bits** (These chunks are **Packets**)
* Packets consist of a **Header** and **Payload**
* **Payload**: The data you want to send which is split up into different packets / chunks
* **Header**: Header holds the instructions to the network for how to handle the packet
  + I.e. Who does it go to and how is it routed, what is the quality that the network should provide for this payload

1. **Internet Address**
2. **Age (TTL: Time To Live)**: To avoid looping, every time it goes through a router it decrements ctr. Packet will be dropped when counter goes to zero.
3. **Checksum to protect header**: For error correction. If bits are flipped, you know how to fix it or you know something is wrong with the data.

* **Switches** help “forward” packets based on their headers.