- Networks

  - Types of networks (social networks, computer networks, entity-relationship networks, …)

  - Node-link diagrams

  - Layered Internet architecture (encapsulation)

- The Internet

  - Structure of the "Internet core" (ISPs, IXP's, CDN's)

  - Packet switching (store and forward, routing)

  - Types of delays (transmission, propagation, queueing, processing)

  - Computing throughput

  - Causes of packet loss (buffer overflow, bit errors, excessive delay)

  - Traceroute

App Layer

- Service Model

  - Example applications (Web, email, streaming video, …)

  - Client-server architecture

  - Processes

  - Sockets

  - Port numbers

  - Designing an application level protocol

- The Web

  - HTTP message formats (GET, Conditional GET, HEAD, POST, DELETE, response)

  - HTTP interaction

  - Sequence diagrams

  - HTTP use of TCP (persistent, non-persistent)

  - Cookies

  - Proxy servers

- Email

  - Email architecture (mail servers, "user agents")

  - Mail message format

- SMTP (message format, interaction)

- POP3 (message format, iteraction)

- Interaction scenario

- 7-bit ASCII limitation

- Socket Programming

  - Creating sockets in Python 3 (UDP, TCP)

- Domain Name System

  - Application "stacking" (one application layer protocol using another)

  - Distributed hierarchical architecture (root servers, TLD servers, authoritative servers)

  - Resource records

  - DNS message format

- Streaming

  - Media coding (audio, video)

  - Quality of service requirements (continuous replay, packet loss, latency, adaptation)

  - Clint-side buffering

  - DASH

Transport Layer

- Common Transport Pieces

- Socket addressing (UDP, TCP)

- Checksums

- UDP

- UDP service goals (unordered, unguaranteed "best effort" delivery)

- Applications that use UDP

- UDP message format

- TCP

- TCP service goals (ordered, guaranteed, eventual delivery)

- Applications that use TCP

- Reliable data transfer (checksums, acknowledgement, timeouts, pipelining)

- Reading Finite State Model diagrams

- TCP message format

- Adaptation (timeout tuning, flow control)

- Overarching skills

- Timing analysis

- Protocol inspection using Wireshark

- Understanding how protocol layers work together

- Understanding why protocols differ

- Designing new protocols

- Protocol implementation

- Understanding the consequences of design decisions (technical, social)

- TCP (Only the following topics, which were not on Exam 1)

- Flow control

- Setting the timeout

- Connection close

Network Layer

- Routers

-    Separation of data and control planes

-    Data plane design (input buffer, bus switch, output buffer)

-    Queueing (FIFO, weighted fair queueing)

- IP

-    Hierarchical IP address space

-    DHCP

-    IPv4 addresses and "Datagram" format

-    Fragmentation

-    Network address translation

-    IPv6

-    Tunneling

- Routing

-    Routing tables (longest prefix matching)

-    Autonomous systems

-    Shortest path routing

-    Border Gateway Protocol (BGP)

Link Layer

- Point to Point

  - Physical layer (twisted pair, coaxial cable, fiber, microwave, satellite)

  - Error detection (CRC)

  - Error correction

- Ethernet

  - Subnets

  - CSMA/CD

  - MAC addresses

  - ARP

  - Ethernet frame structure

  - Switched Ethernet

Wireless

- WiFi

- CSMA/CA (SIFS, DIFS, RTS, CTS)

- Physical layer issues (signal strength, multipath, interference, hidden terminal)

- Adaptive rate selection

- Association (SSID)

- 802.11 frame structure

- Power management

- Mobile Data

- 4G architecture

- Combination of FDMA and TDMA

- CDMA

- Handoffs

- Roaming mobility (indirect routing)

Security

- Hacking

  - Bots and botnets

  - Distributed denial of service attacks

  - Ransomware

  - Social attacks

  - Disinformation

- Firewalls

  - Firewalls (stateful, stateless)

  - Gateways

  - Intrusion detection

- Encryption

  - Symmetric key encryption

  - Public key encryption

  - PGP for email

  - SSL (and TLS)

- Authentication

  - Hash

  - Message Authentication Codes

  - Digital signatures

  - Man-in-the-middle attacks

  - Certificate authorities

Social Issues

- Appropriate Use

  - Legal system (constitution, laws, regulations, treaties)

  - Contracts (e.g., terms of service)

  - Policy (e.g., privacy policies)

  - Norms

  - Technical means

  - Jurisdiction

  - Controlling collection vs. controlling use

  - Balancing interests

- Privacy

  - FISA Section 702

  - Upstream collection

  - About collection

  - Multi-communication transactions

- Twitter

  - Agile development methods

  - Adoption of innovation (social structure, social structure, predictors)

  - Financing

- The Interplanetary Internet

  - Interplanetary propagation delays

  - Interplanetary queueing delays

  - Delay tolerant networking

  - Sneakernet

  - Edge caching

- Global Internet Access

  - Demographic challenges

  - Spatial challenges

  - Last-mile technology (Fiber, radio, drones, balloons, …)

  - Context-sensitive design