- network layer
  - Data Plane (forwarding)
    - Local, per-router function determines how datagram arriving on router input port is forwarded to router output port
  - IP
    - Packet Structure
      - overhead = 20 bytes tcp + 20 bytes of IP + app layer overhead
    - Potential problem for routers
      - Loop: TTL
      - Header Corruption: checksum
      - Packet too large: Fragmentation
    - Fragmentation
      1. break up datagram in size that output link can support
      2. copy IP header to pieces
      3. set MF (More fragments) flag on pieces except the last one
      4. set offset to indicate position (divide by eight when calculate)
      5. Re-compute checksum
    - Assembly
      - Receiving host uses identification field with MF offsets to complete the datagram
    - Addressing
      - 32 bits: higher: network, lower bits: host part
      - network: can physically reach each other without intervening a router
      - Mask: get the net work part
      - Class-ful address
        - A: starts with 0; 0 - 8 net bits
        - B: starts with 10; 0 - 16 net bits
        - C: starts with 110; 0 - 24 net bits
        - D: starts with 1110; multicast address
        - E: starts with 1111; reserved for future use
      - Subnetting: also contained in mask bits
      - CIDR addressing
        - Class InterDomain Routing: format: a.b.c.d/x
        - Longest prefix matching
    - DHCP: Dynamic Host Configuration Protocol
      - Goal
        - can renew its lease on address in use
        - Allows reuse of addresses
        - Support for mobile users who wants join
      - Overview
        1. Host broadcast "DHCP discover"
        2. DHCP sever reply with "DHCP offer"
        3. host request "DHCP request"
        4. DHCP servrer respond with "DHCP ACK"
      - More than IP address:
        - address of first hop router
        - name and IP address of DNS sever
        - network mask
    - NAT: network address translation
      - outgoing datagram: replace(source IP address, port #) of every outgoing datagram to (NAT IP address, new port #)
      - remember (in NAT translation table)
      - incoming datagrams: replace
      - Advantage:
        - range of addresses not needed from ISP
        - can change address of devices
        - can change ISP without changing addresses of devices in local network
      - Disadvantage:
        - change internet to connection oriented
        - violates the architectural model of IP
  - Control plane (routing)
    - network-wide logic determines how datagram is routed among routers along end-end path from source host to destination host
    - traditional routing algorithms:
      - Internet Routing
        - Each AS runs an intra-domain routing protocol that establishes routes within its domain
        - ASes participate in an inter-domain routing protocol that establishes routes between domains -> Path Vector, e.g., Border Gateway Protocol (BGP)
      - link state (Global)
        - Routers maintain cost of each link in the network
        - Connectivity/cost changes flooded to all routers
        - Converges quickly (less inconsistency, looping, etc.)
        - Limited network sizes
      - distance vector (DV) (Decentralized)
        - Routers maintain next hop & cost of each destination.
        - Connectivity/cost changes iteratively propagate form neighbour to neighbour
        - Requires multiple rounds to converge
        - Scales to large networks
    - software-defined networking (SDN) centralised

- link state Routing algorithm
  - Flooding LSAs (Link State Advertisement)
  - Use Dijistra's Algo
  - Forwarding table: (Destination I Link)
- Distance vector Algorithm
  - Bellman-Ford equation:
    let
    dx(y) := cost of least-cost path from x to y
    then
    dx(y) = min {c(x,v) + dv(y) }