- network
  - Main Topic 7
    - before midterm
      - basic ideas
        - packet switching
        - statistical multiplexing
        - layering
      - link layer
        - channel capacity
        - framing
          - frames — complete link layer mes…
        - bootstrapping
          - DHCP protocol
        - Address resolution protocol (ARP)
        - latency
        - encoding and clock recovery
        - error detection/correction
        - ethernet switching
      - network layer
        - Subnetting and supernetting allow hiding details of internal networks from the rest of the world. → simplify the network
        - fragmentation
          - Screenshot 2025-04-25 at 11.11.16 PM.png
        - hop by hop packet forwarding
        - bellman-ford
          - Screenshot 2025-04-25 at …
        - dijkstra
          - Screenshot 2025-04-25 at 11.48…
        - addresses and lookups
        - IGP
          - Screenshot 2025-04-26 at 1.02.41 AM…
        - BGP
          - Screenshot 2025-04-26 at 1.07.13 AM…
          - Subtopic 2
      - transport layer
        - flow control
        - congestion control
        - retransmissions and sliding windows
        - congestion avoidance (RED)
    - 7 congestion control
      - congestion control definition — a set of sender overload the ne…
      - congestion collapse
        - definition — increase in network load … of useful work done
        - causes
          - retransmission of packets …
          - undelivered packets …
      - what we want
        - high throughput
          - measurement of the pe…
          - number of bit/second …
        - low delay — the time required to deliver a …
      - load, power, delay — power
        - rtload/delay
        - metric for how well the netw…
        - goal is maximize power
      - fairness — equal share of bandwidth
      - resource allocation vs congestion control
      - simple congestion detection
        - packet loss: packet get dropped …
        - packet delay: packet experienc…
      - options for congestion control
        - implemented by host vs netw…
        - reservation based vs feedbac…
        - window based vs rate based
      - TCP congestion control
        - TCP implements host based, feedback … and window based congestion contro…
        - TCP sources attempts to determine … capacity is available
        - TCP sends packets and react to ob… event (loss)
        - idea
          - each source determine th…
          - congestion window
        - TCP sending rate
          - acknowledg… after one RT…
          - Amount of d… window size…
          - R = W / RTT
          - As W increase … delay increase … constant
        - slow start phase
          - sender starts … overloading …
          - increase the …
          - until the first …
        - two kind of loss in TCP
          - triple d…
          - timeout …
        - repeat slow starting after idle peri…
      - Nagle's Algorithm
        - motivation
          - interactive application …
          - small packets are waste…
          - appealing to reduce the …
          - need to balance compe…
        - algo
          - the amount of data is smaller …
          - some other packet is already …
          - (send all most one small pac… waiting until all outstanding… arrived)
        - impact on performance
          - interactive …
          - (build trans… drynes)
      - delayed ACK
        - motivation
          - TCP traffic is often bi-directi…
          - ACK packet have very high o…
          - piggybacking is appealing …
        - TCP header allows piggybacking (捎带发送)
        - increase the likelihood of piggybacking
        - delay sending an ack
          - upon receiving a p… (typically 200ms) …
          - if the application g… send
          - if the timer expires… ACK
        - Limit the wait
          - timer of 200msec or 500m…
          - ACK every other full sized …
      - active queue management can help
        - random early detection (R…
        - explicit congestion notific…
    - 8.1 Active queuing mechanisms (AQM)
      - end-to-end principle
        - design principle for … keep functionalities …
        - power at end hosts …
      - drop tail queuing leads to bursty loss
      - random early detection (RED)
        - basic idea
        - packet d…
        - property …
        - problem …
      - explicit congestion notification (ECN)
      - detour: Open TCP
        - Network can impact cong… using Active queuing …
        - network help in the …
    - 8.2 middleboxes
      - motivation
        - network layer principles
          - global unique iden…
          - simple packet forw…
        - internet reality
          - host mobility — change in IP…
          - IP address depletion(耗尽)
          - security concerns
            - discard…
            - detecti…
          - performance concerns
      - middleboxes
        - intermediaries
          - interposed in between the com…
          - often without knowledge of on…
        - two view
          - an abomination
            - violation of la…
            - cause confusi…
            - responsible fo…
          - a necessity
            - solving real and pr…
            - needs that are not m…
        - Network address translation (NAT)
          - IP head…
          - when to … destinati…
          - maintain…
          - objectio…
          - Network Address Translation Example
          - where o…
        - firewalls
          - definition — isolate organization's … internet, allowing som… blocking others
          - internet attack
            - denial of servic…
            - break in
          - packet filtering
            - internal interne… firewall
            - firewall filter p…
          - firewall configuration
            - firewall p…
            - each rule…
            - order ma…
          - traffic management
            - classify th…
            - then handl…
            - traffic sha…
            - separate q…
          - firewall implementation challenge
            - traffic manage…
            - firewall implem…
          - application gateway (应用网关网关)
        - web proxies
          - web is a client server protocol (S…
          - proxy play both roles
            - a ser…
            - a cli…
          - proxy caching
          - getting request to the proxy
          - other functions
            - anonymizi…
            - transcoding …
            - prefetching …
            - filtering …
        - pros and cons
          - pros
            - using fewer IP addre…
            - blocking unwanted tr…
            - making fair use of ne…
            - improving web perfo…
          - cons
            - no longer globally u…
            - no longer can assum… packets
    - 9 software defined network
      - compare with computer application
        - vertically integra…
        - complex
        - closed
        - proprietary
        - networking indus…
        - reality: specializ…
        - horizontal, open …
      - what we need
        - 1. separate intelligence from datapath
        - 2. cache decisions — in minimal flow …
      - Software defined network (SDN)
        - 1.Open interface to p…
        - 2.at least one netwo… and closed source
        - 3.consistent, up-to-d…
        - Software Defined …
      - consequence
        - more innovation in network services
        - lower barrier to entry for competition
        - lower cost
          - infrastructure
          - management
      - example — routing — Example: Routing
      - network OS
        - a distributed system that create a consi… update network view
        - runs on the server (controller) in the netw…
        - uses forwarding abstraction to …
      - control program
        - a program that operate on view of …
        - input — global network view (g…
        - output — the configuration for …
        - control program is not necessarily a … system
        - Software Defined Network (SDN)
      - forwarding abstraction
        - purpose
          - abstract awa…
          - flexible
          - minimal
        - openFlow is an example of …
      - forwarding substrate 转发平面
        - flow-based
        - a small number of …
        - open api to flow tab…
        - What is a Flow?
        - substrate: flow-spac…
      - openflow
        - a protocol
        - openflow switch
        - openflow rules
        - plumbing primitives
        - OpenFlow Usage Example
      - challenge
        - change hardware
        - change expertise — less old people, m…
      - opportunity
        - **Programmability**
          - Easily customize network behavior throu… software.
        - **Centralized Control & Global View**
          - Optimize traffic with a centralized contr… having full network visibility.
        - **Rapid Innovation**
          - Quickly deploy new features and protoc… without hardware changes.
        - **Automation & Cost Reduction**
          - Automate configuration and manageme… lowering operational costs.
        - **Fine-Grained Flow Control**
          - Precisely control traffic at any granular… (MAC, IP, ports).
        - **Enhanced Security & Isolation**
          - Implement dynamic security policies and … network segmentation.
        - **Network Virtualization**
          - Support multi-tenancy with virtual netw… shared infrastructure.
        - **Integration with Machine Learning**
          - Use ML for traffic optimization, anomal… detection, and predictive analytics.
    - 10 machine learning and network
      - Data center network (DCN)
        - definition — a model … resou…
        - functions
          - data …
          - appl…
          - data …
        - design dimensions
        - network architecture
          - Three-Tier Architecture
          - Traffic Direction in 3-Tier Architecture
          - Fat-Tree Architecture
          - Other DCN Architectures/Topologies
        - transport in data cen…
        - Link layer flow contr…
      - network for machine learning
        - challenge
        - opportunity
        - network topology
        - application aware…
        - network aware ap…
    - 11. overlay network
      - a logical network that built on top of a physical network — overlay links are … underlying network…
      - many logical network may coexist at one …
        - over the same und…
        - and providing its o…
      - nodes are often end hosts
        - acting as intermediate nodes tha… traffic
        - providing a service, such as acce…
      - who control the nodes providing services
        - the party providing t…
        - distributed collection…
      - routing overlay
        - an alternating routing strategy
          - no appli… nodes
          - packet d… strategie…
        - incremental enhancement to IP
          - IPv6
          - multica…
          - mobility…
          - security…
        - revisiting where a function belongs — end…
        - customized path selection — resilient over…
      - IP tunneling
        - IP tunnel is a virtual point to point link
        - encapsulation of the picket inside an IP datagram
      - 6 bone — 6Bone: Deploying IPv6 over IP4
      - TCP tunneling — encapsulate IP packets inside a new TCP pack…
      - secure communication over insecure links
        - encrypt packets a…
        - eavesdropper can… 法截获数据
      - tor project
        - an overlay to enhance anonymity and privacy
        - how it work
          - obtain a list of tor nodes from a …
          - pick a random path to destinatio…
          - select a different path for other …
      - communicating with mobile users — fixed gateway forwards …
      - MBone: IP multicast IP组播
        - multicast
          - delivering the sam…
          - avoid sending the …
          - MBone: IP Multi…
        - ip multicast
          - special addres… schemes
          - not widely dep… between nodes
      - end system multicast — multicast tree of end hosts
      - RON resilient overlay network
        - premise — by building ap… increase perfo…
        - RON Can Outperform …
        - RON: Resilient Overlay …
      - peer to peer networks
        - napster
          - file transfer is decentral…
          - but locating content i… (central directory)
        - gnutella
          - query flooding
          - fully distributed
          - public domain protoco…
          - overlay network
          - cons
            - scalability …
            - peer joining …
            - search scop…
            - search time …
            - high overhe…
          - pros
            - fully decen…
            - search cost …
            - processing … semantics
        - KaZaA
          - smart query flooding …
          - KaZaA: Motivation for …
        - bittorrent
          - simultaneous down…
          - BitTorrent Co…
          - BitTorrent: Ov…
          - Free-Riding Pr…