**Application Layer (Email, DNS, P2P)**

* Email
  + User Agent -- composing, editing, reading mail messages
  + Mail servers
    - Mailbox contains incoming messages for user
    - Message queue of outgoing mail messages
  + SMTP (Simple mail transfer protocol)
    - Uses TCP to reliably transfer email message from client to server, port 25
    - 3 phases of transfer
      * Handshaking → Transfer of messages → Closure
    - command/response interaction 命令/响应
      * Commands: ASCII text
      * Response: status code and phrase
    - Uses persistent connections
    - Requires message (header & body) to be in 7-bit ASCII
    - Uses CRLF.CRLF to determine end of message
  + HTTP vs SMTP
    - Both have ASCII command/response interaction, status codes
    - Push vs Pull
    - each object encapsulated in its own response msg (HTTP) VS
    - multiple objects sent in multipart msg (SMTP)
  + Mail message format
    - Header -- To, From, Subject (Different from SMTP MAIL -- FROM, RCPT, TO)
    - Body -- ASCII only
    - 多媒体邮件扩展 MIME -- 通过在邮件头部增加额外的行以声明MIME的内容类型
  + Mail access protocols 访问协议 (说明 协议可以一起用)
    - SMTP -- delivery/storage to receiver’s server
    - Retrieval from server
      * POP (Post Office Protocol) 无状态
        + Authorization, download
      * IMAP (Internet Mail Access Protocol) 有状态
        + More features, including manipulation of stored messages on server
      * HTTP(S)
        + Gmail, Yahoo! Mail, etc
* DNS (Domain Name System) 能将域名翻译成IP地址
  + Distributed database 分布式数据库
    - Implemented in hierarchy of many name servers
  + Application-layer protocol -- address/name translation
    - Core Internet function, implemented as application-layer protocol (Intenet核心功能，用应用层协议实现)
    - Complexity at network “edge”
  + Services
    - Hostname to IP address translation
    - Host aliasing
    - Mail server aliasing
    - Load distribution 负载均衡
      * Replicated Web servers: many IP addresses correspond to one name
      * Content distribution networks: use IP address of requesting host to find best suitable server. E.g. closest, least-loaded, etc.
  + Structure
    - Why not centralize DNS? Ans: doesn’t scale
      * Single point of failure
      * Traffic volume
      * Distant centralized database
      * Maintenance
    - Hierarchy
      * Hierarchical namespace
        + Name is leaf-to-root path e.g. webcms3.cse.unsw.edu.au
        + Depth is arbitrary (limit 128)
      * Hierarchically administered
      * Hierarchy of servers
        + Root server -- com, org, net, edu etc.
        + TLD (Top-level domain) servers -- cn, uk, fr, au etc.

Network solutions maintains com

Educause maintains edu

* + - * + Authoritative DNS servers 权威域名服务器(组织的域名解析服务器)

Maintained by organization or server provider

* + - * Local DNS
        + Does not strictly belong to hierarchy
        + Each ISP has one (default name server)
        + When host makes DNS query, query is sent to its local DNS server

Acts as proxy, forwards query into hierarchy

* + DNS name resolution
    - Iterated query 迭代
    - Recursive query 递归
  + DNS: Caching, updating records
    - Once name server learns mapping, it caches mapping
      * Timeout after some time (TTL)
      * TLD servers typically cached in local name servers
        + Thus, root name servers not often visited
    - Cached entries may be out-of-date 记录的更新/通知机制
  + DNS records -- distributed db storing RR (resource records)
    - RR format (name, value, type, TTL)
    - Type = A (name=hostname, value=IP address)
    - Type = NS (name=domain(edu.cn), value=hostname of authoritative name server for this domain)
    - Type = CNAME (name=alias name 别名, value=canonical name 真名)
    - Type = MX (value=name of mail server associated with name)
  + DNS protocol, messages
    - Query/reply messages, both with the same message format
    - Header
      * Identification -- 16 bits, reply use the same #
      * Flags
  + DNS 运行在UDP上，使用53端口号
  + Inserting records to DNS
    - Create authoritative server type A record for www.networkuptopia.com; type MX record for networkutopia.com

