Computer Networks
COL 334/672

Application Layer: Email and DNS

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Recap: Application Layer

- HTTP
- Email
- DNS
- P2P
- Video streaming

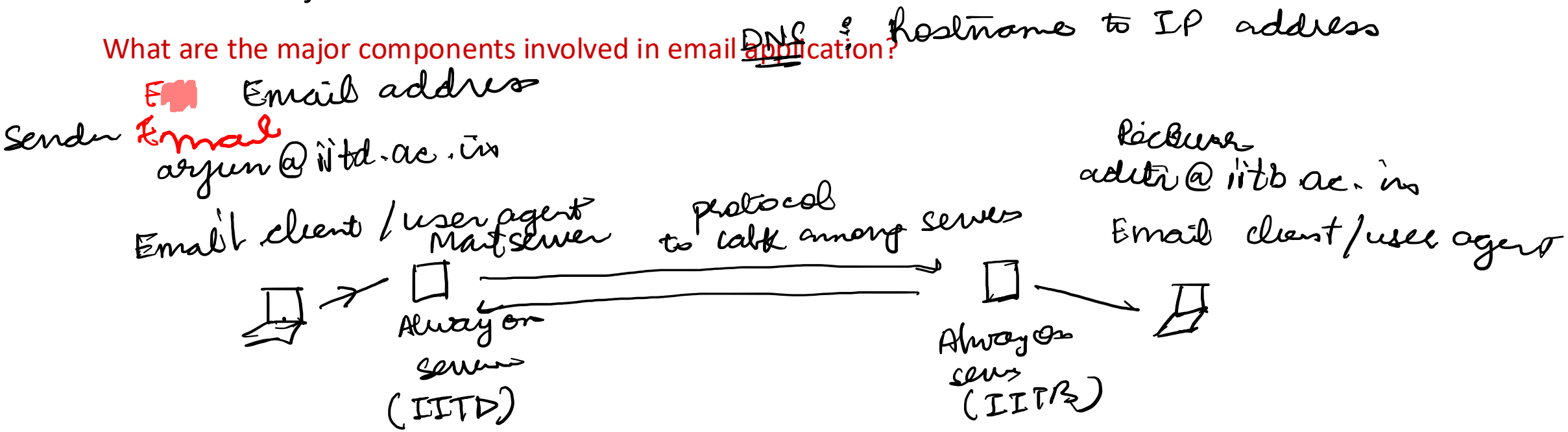
Email

- First “killer” application over the Internet

Journey of an Email

- Scenario: Arjun from IITD wants to send an email to his friend Aditi in IITB

What are the major components involved in email application?



Three major components:

- user agents
- mail servers (SMTP / IMAP)
- simple mail transfer protocol: SMTP

Mail message format

SMTP: protocol for exchanging e-mail messages, defined in RFC 5321 (like RFC 7231 defines HTTP)

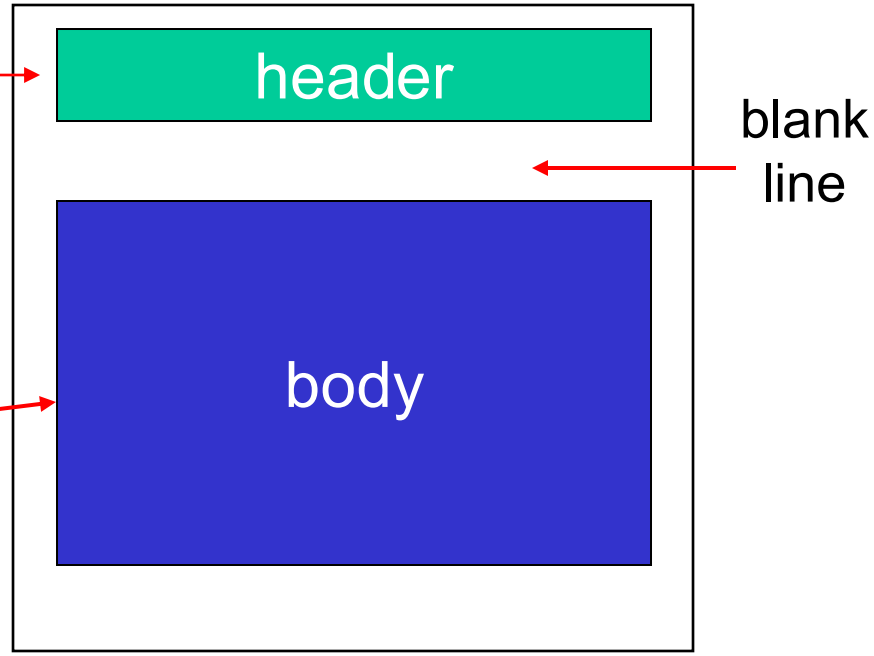
RFC 2822 defines *syntax* for e-mail message itself (like HTML defines syntax for web documents)

- header lines, e.g.,
  - To:
  - From:
  - Subject:

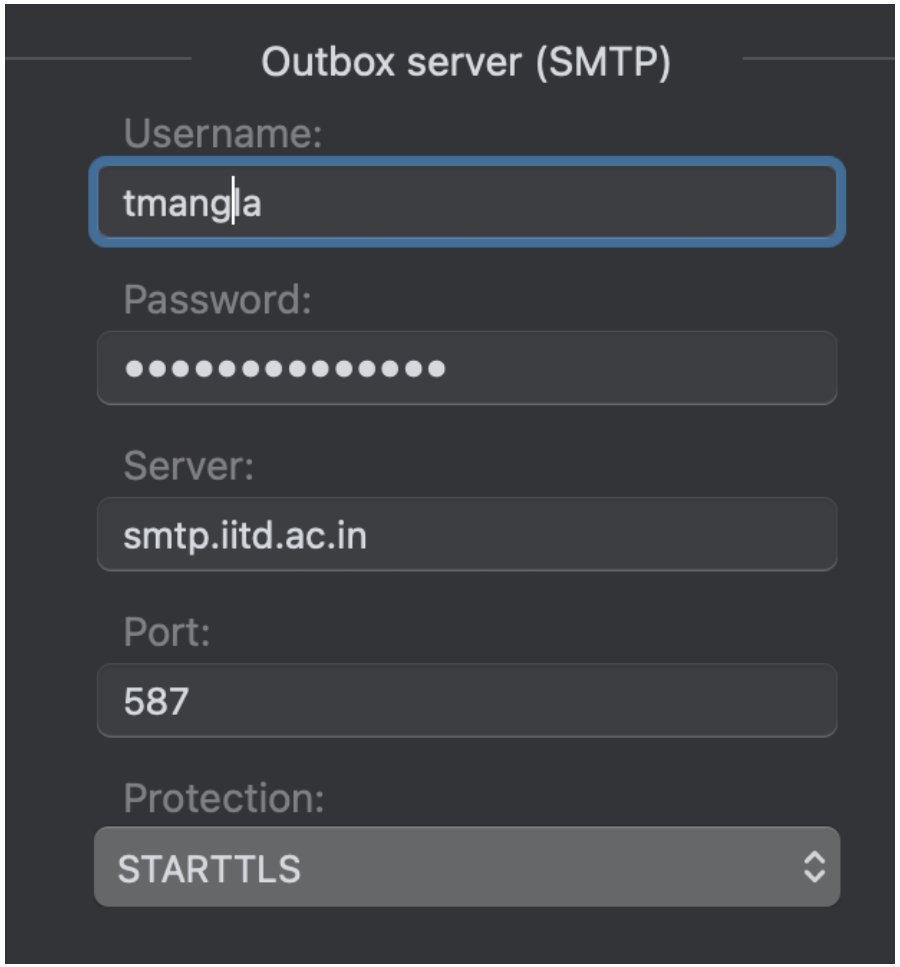
  these lines, within the body of the email message area different from SMTP MAIL FROM:, RCPT TO: commands!
- Body: the "message" , ASCII characters only

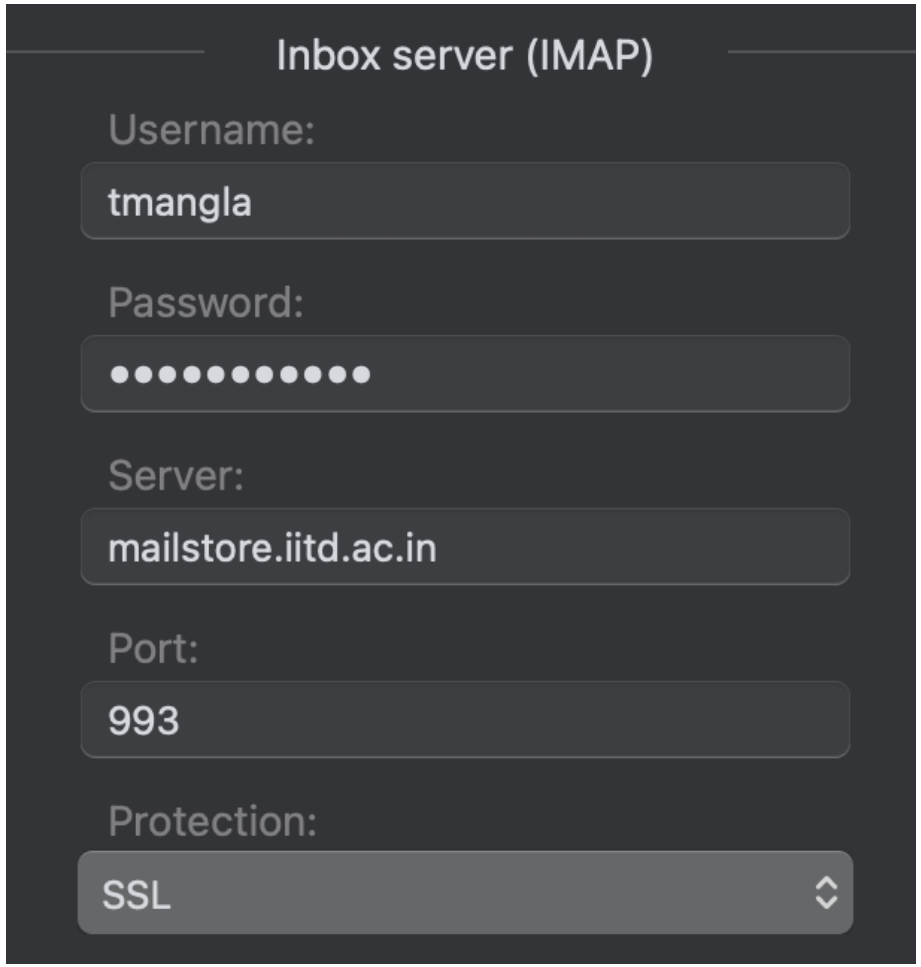
attaching an objects

cc / bcc



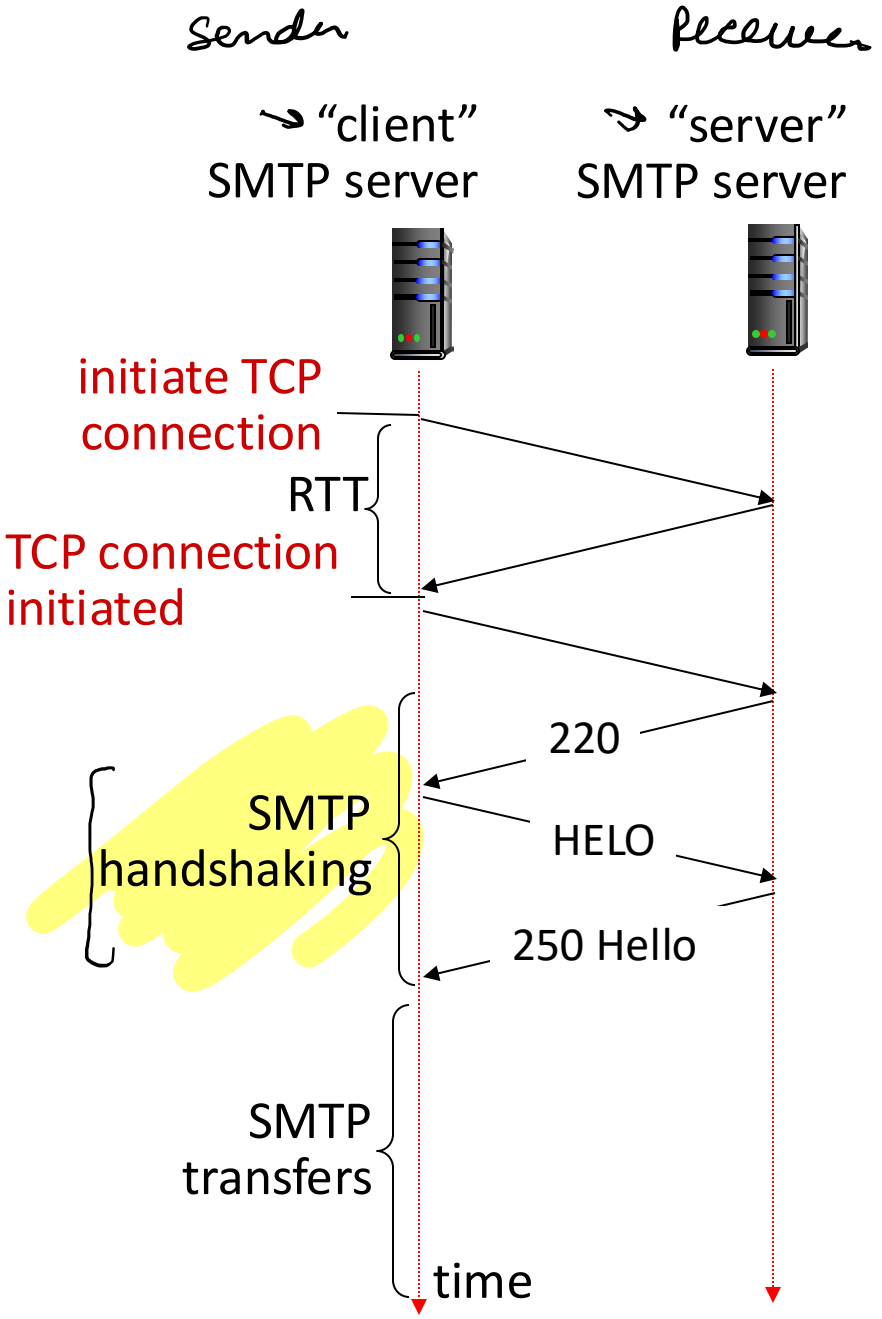
Configuring Mailbox



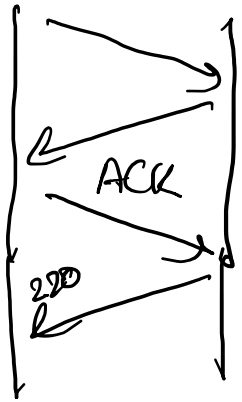


SMTP RFC (5321)

- uses TCP to reliably transfer email message from client (mail server initiating connection) to server, port 25
  - direct transfer: sending server (acting like client) to receiving server
- three phases of transfer
  - SMTP handshaking (greeting)
  - SMTP transfer of messages
  - SMTP closure
- command/response interaction (like HTTP)
  - commands: ASCII text
  - response: status code and phrase



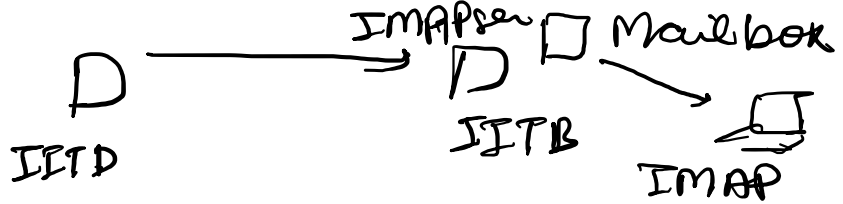
Sample SMTP Interaction



S: 220 mail.iitb.ac.in

```
C: HELO mail.iitd.ac.in
S: 250 mail.iitb.ac.in Hello mail.iitd.ac.in, pleased to meet you

C: MAIL FROM:<user@iitd.ac.in>
S: 250 2.1.0 Sender OK

C: RCPT TO:<student@iitb.ac.in>
S: 250 2.1.5 Recipient OK

C: DATA
S: 354 Start mail input; end with <CRLF>.<CRLF>

C: Subject: Collaboration Request
C: From: user@iitd.ac.in
C: To: student@iitb.ac.in
C:
C: Hello, I would like to discuss a research collaboration.
C: .
S: 250 2.0.0 Message accepted for delivery

C: QUIT
S: 221 2.0.0 mail.iitb.ac.in closing connection
```

Configuring Mailbox



Outbox server (SMTP)

Username:
tmangla

Password:
••••••••••••••

Server:
smtp.iitd.ac.in

Port:
587

Protection:
STARTTLS

Inbox server (IMAP)

Username:
tmangla

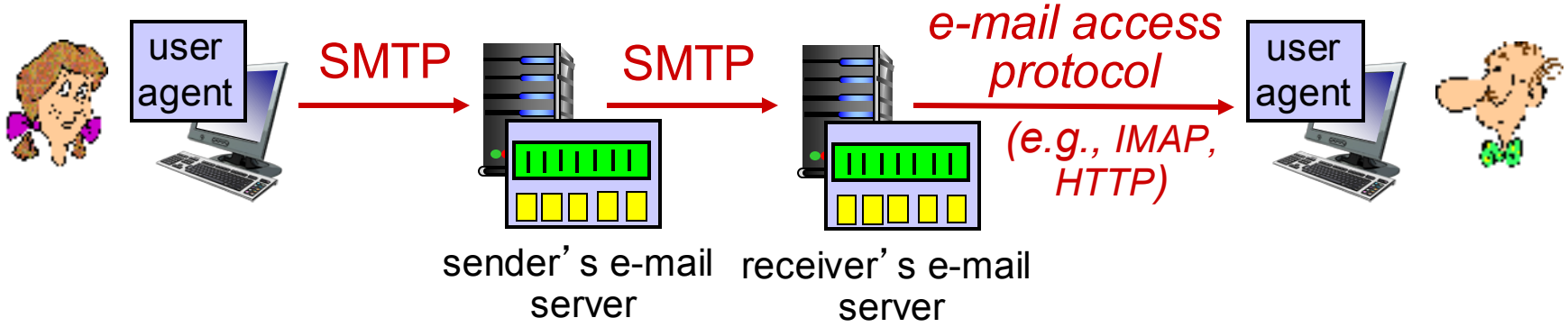
Password:
••••••••••••

Server:
mailstore.iitd.ac.in

Port:
993

Protection:
SSL

Retrieving email: mail access protocols



- SMTP: delivery/storage of e-mail messages to receiver's server
- mail access protocol: retrieval from server
  - IMAP: Internet Mail Access Protocol [RFC 3501]: messages stored on server, IMAP provides retrieval, deletion, folders of stored messages on server
- HTTP: gmail, Hotmail, Yahoo!Mail, etc. provides web-based interface on top of STMP (to send), IMAP (or POP) to retrieve e-mail messages

SMTP: observations

comparison with HTTP:

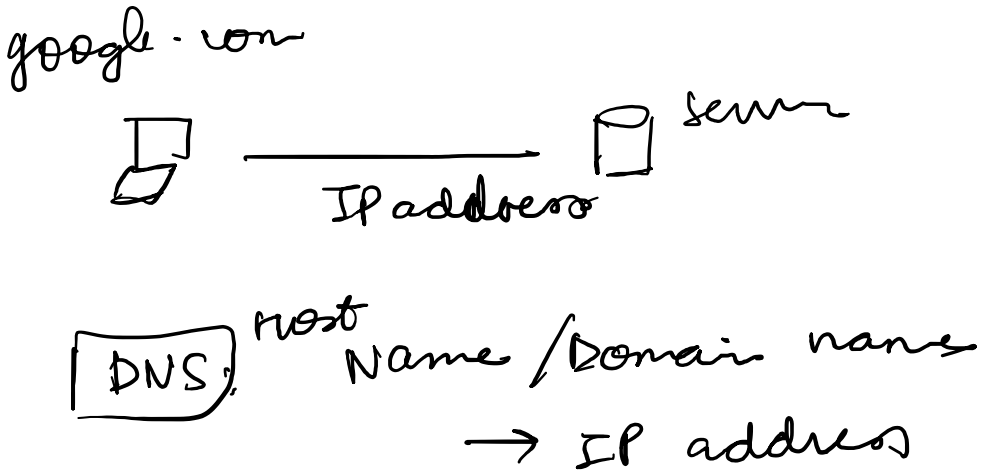
- HTTP: client pull
- SMTP: client push
- both have ASCII command/response interaction, status codes
- HTTP: each object encapsulated in its own response message
- SMTP: multiple objects sent in multipart message

SMTP/Email:

- Open standards
- Interoperability among email clients
- Exemplify the design spirit of Internet

Recap: Application Layer

- HTTP
- Email
- **DNS** → Domain Name System
- P2P
- Video streaming



DNS: Domain Name System

DNS: database
① Dynamic → consistency
② store a large # of domain name
③ low latency
④ reliable

- Humans understand names (google.com),
- Internet hosts, routers understand IP address (12.123.12.12)
- *Q:* how to map between IP address and name, and vice versa ?

Domain Name System (DNS):

- *phone book* of the Internet
- *application-layer protocol:* hosts, DNS servers communicate to *resolve* names (address/name translation)
  - *note:* core Internet function, implemented as application-layer protocol
  - complexity at network's "edge"

DNS: Design Goals

Large number of host names

- ~ billion records, each simple

handles many *trillions* of queries/day:

- *many* more reads than writes
- *performance matters:* almost every Internet transaction interacts with DNS - msecs count!

reliability

How do we go about designing such a system?

can you keep the database on a single machine?

→ SPF
→ storage
→ slow server
→ non-technical

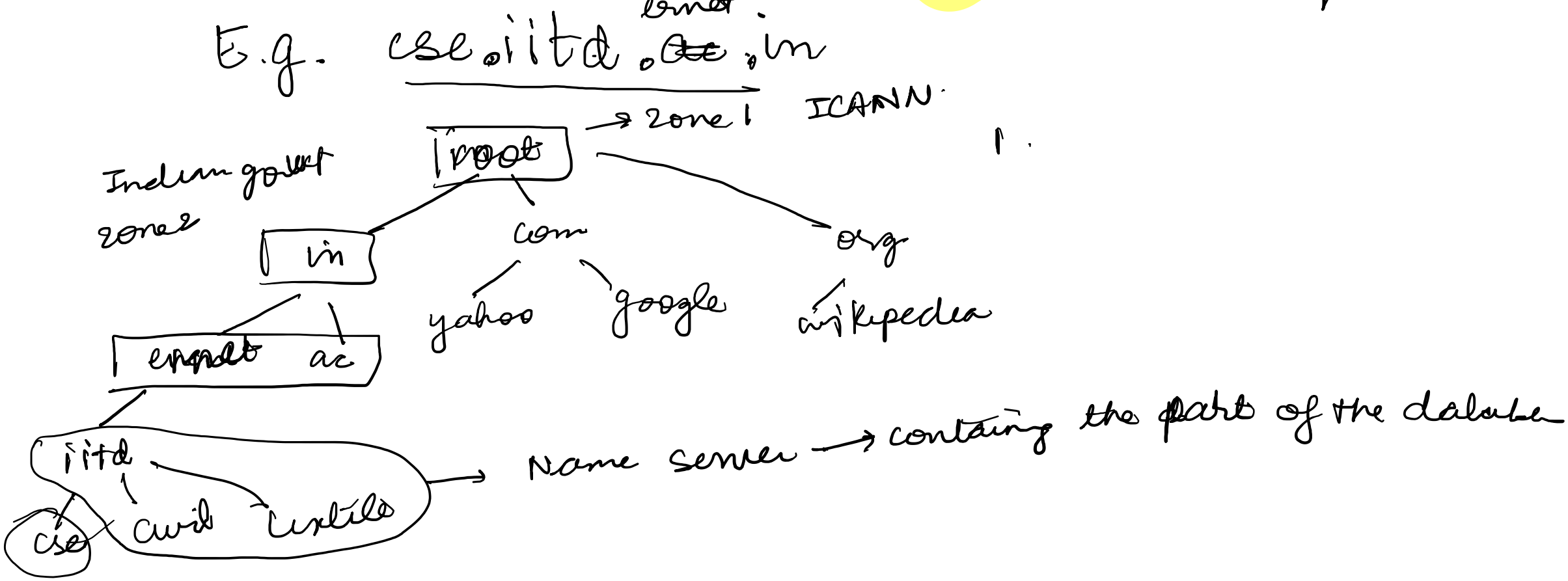
Approach 1: Centralized DNS

- single point of failure
- traffic volume
- maintenance
- ..

Decentralized and distributed system

- Q: On what basis to decentralize?

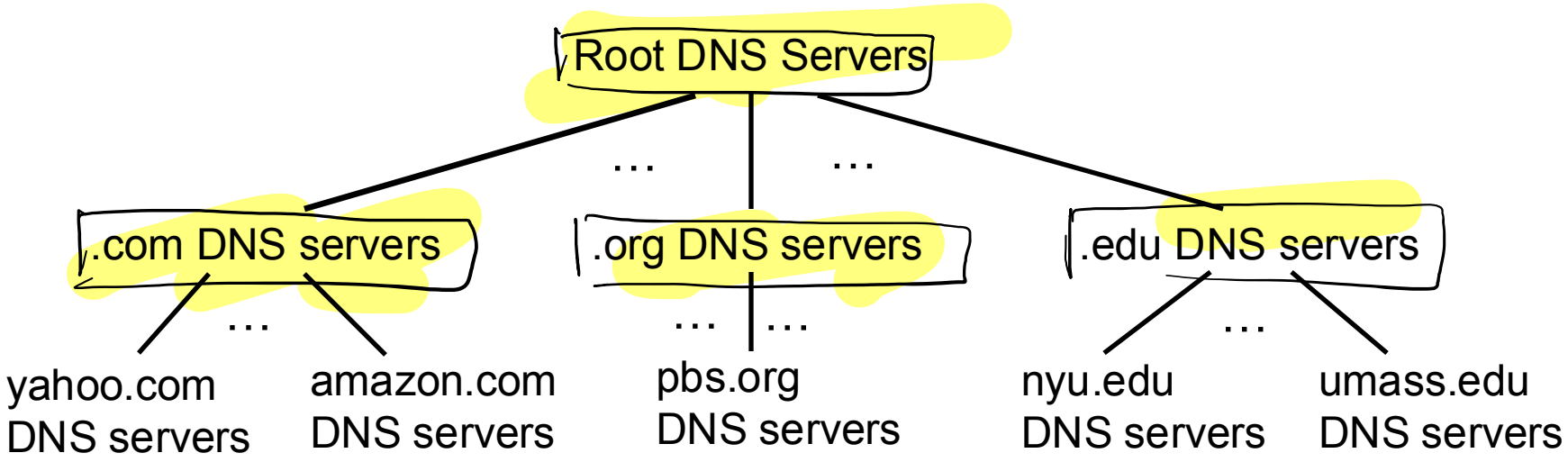
Hierarchical domain name space



Decentralized and distributed system

- Q: On what basis to decentralize? Hierarchical domain name space
- Partition domain name hierarchy into zones managed by some authority
  - E.g., ICANN is responsible for storing information about top-level domains
- Each zone corresponds to a name server

Name servers



Root

Top Level Domain

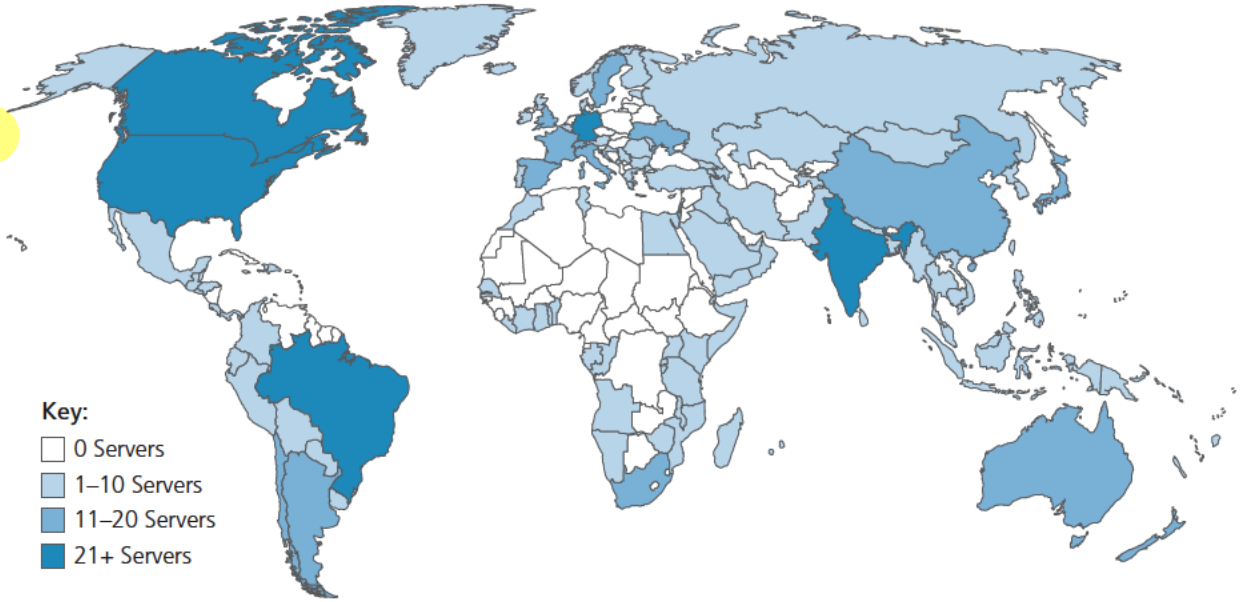
Authoritative

- Name servers are replicated and may be geographically distributed for reliability

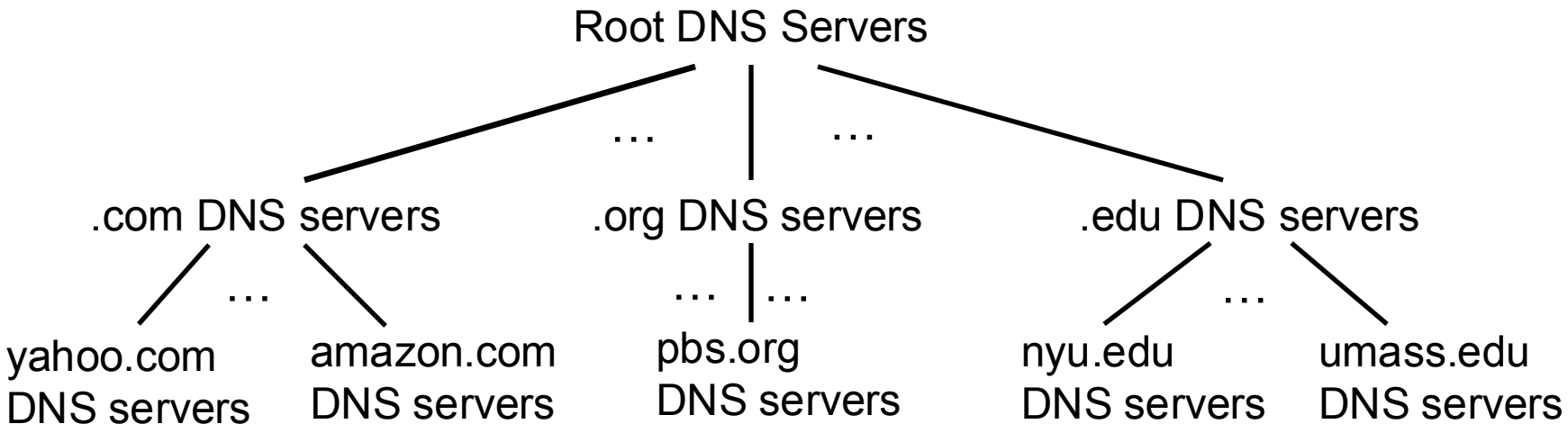
DNS: root name servers

- official, contact-of-last-resort by name servers that can not resolve name
- *incredibly important* Internet function
  - Internet couldn't function without it!
  - DNSSEC – provides security (authentication, message integrity)
- ICANN (Internet Corporation for Assigned Names and Numbers) manages root DNS domain

13 logical root name "servers" worldwide each "server" replicated many times (~200 servers in US)



Name servers



Root

Top Level Domain

Authoritative

- Name servers are replicated and may be geographically distributed for reliability
- Name server implements zone information as collection of resource records

DNS records

DNS: distributed database storing resource records (RR)

RR format: (`name`, `value`, `type`, `ttl`), class

type=A

- `name` is hostname
- `value` is IP address

type=NS

- `name` is domain (e.g., foo.com)
- `value` is hostname of authoritative name server for this domain

type=CNAME

- `name` is alias name for some "canonical" (the real) name
- www.ibm.com is really servereast.backup2.ibm.com
- `value` is canonical name

type=MX

mail server records

- `value` is name of SMTP mail server associated with `name`

Example

Root Name server

① . in , dns . xyz . in , NS, TTL

② dns . xyz . in , 112 . 112 . 112 . 112 , A ,

③ com , dns . xyz . com , NS

④ dns . xyz . com , 113 . 113 . 113 . 113 , A

IN name server

. ernet . in , dns . ernet . in
NS

dns . ernet . in , x . y . z . w , A

How to do name resolution?

Censorship : DNS

Public DNS resolver
: 8.8.8.8
1.1.1.1 → Cloudflare resolver

Local DNS name servers

- when host makes DNS query, it is sent to its *local* DNS server
  - Local DNS server returns reply, answering:
    - from its local cache of recent name-to-address translation pairs (possibly out of date!)
    - forwarding request into DNS hierarchy for resolution
  - each ISP has local DNS name server; to find yours:
    - MacOS: `% scutil --dns`
    - Windows: `>ipconfig /all`
- local DNS server doesn't strictly belong to hierarchy