Network Applications: DNS

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http://zoo.cs.yale.edu/classes/cs433/

2/1/2016

Outline

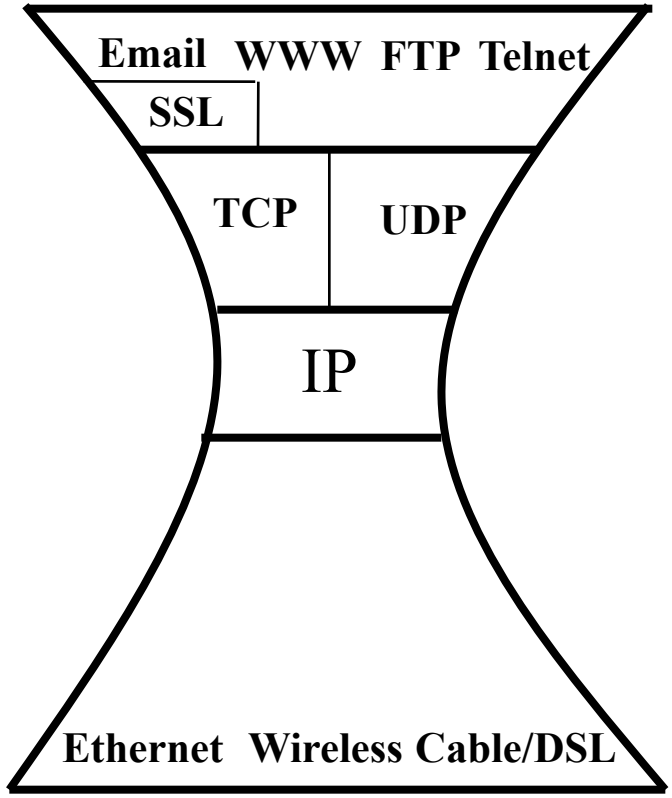
- Admin and recap
- DNS

Admin

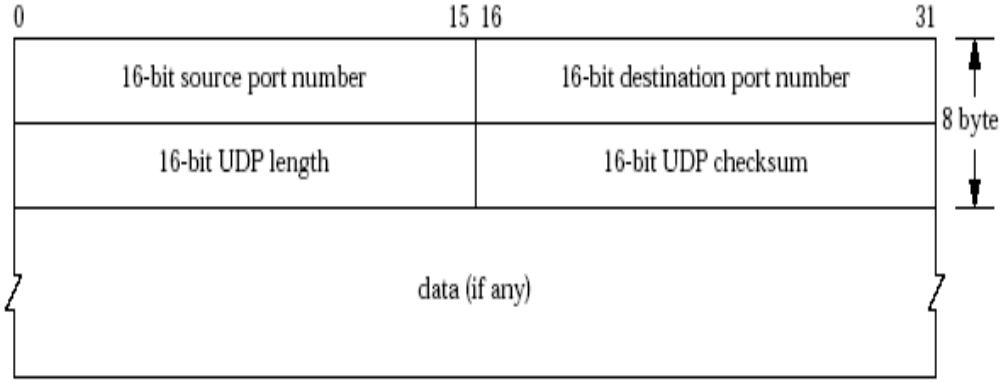
- 72 discretionary late hours for assignments across the semester

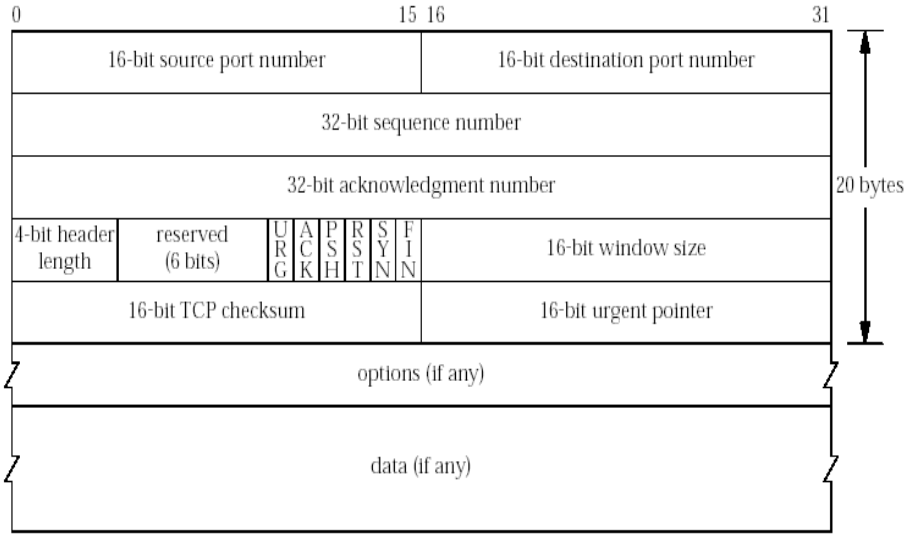
Recap: The Big Picture of the Internet

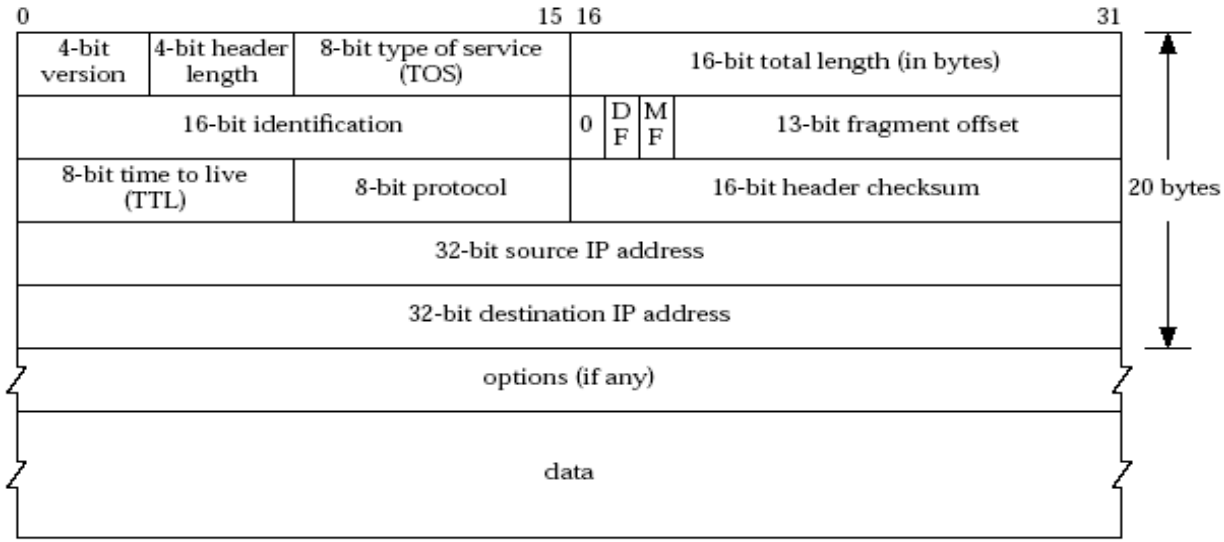
- Hosts and routers:
  - ~ 1 bill. hosts (2015)
  - organized into ~50K networks
  - backbone links 100 Gbps
- Software:
  - datagram switching with virtual circuit support
  - layered network architecture
    - use end-to-end arguments to determine the services provided by each layer
  - the hourglass architecture of the Internet

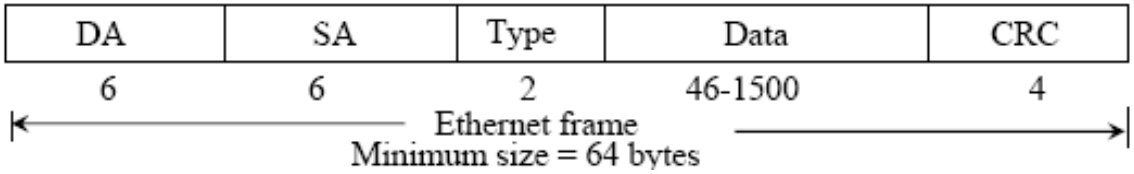


Protocol Formats

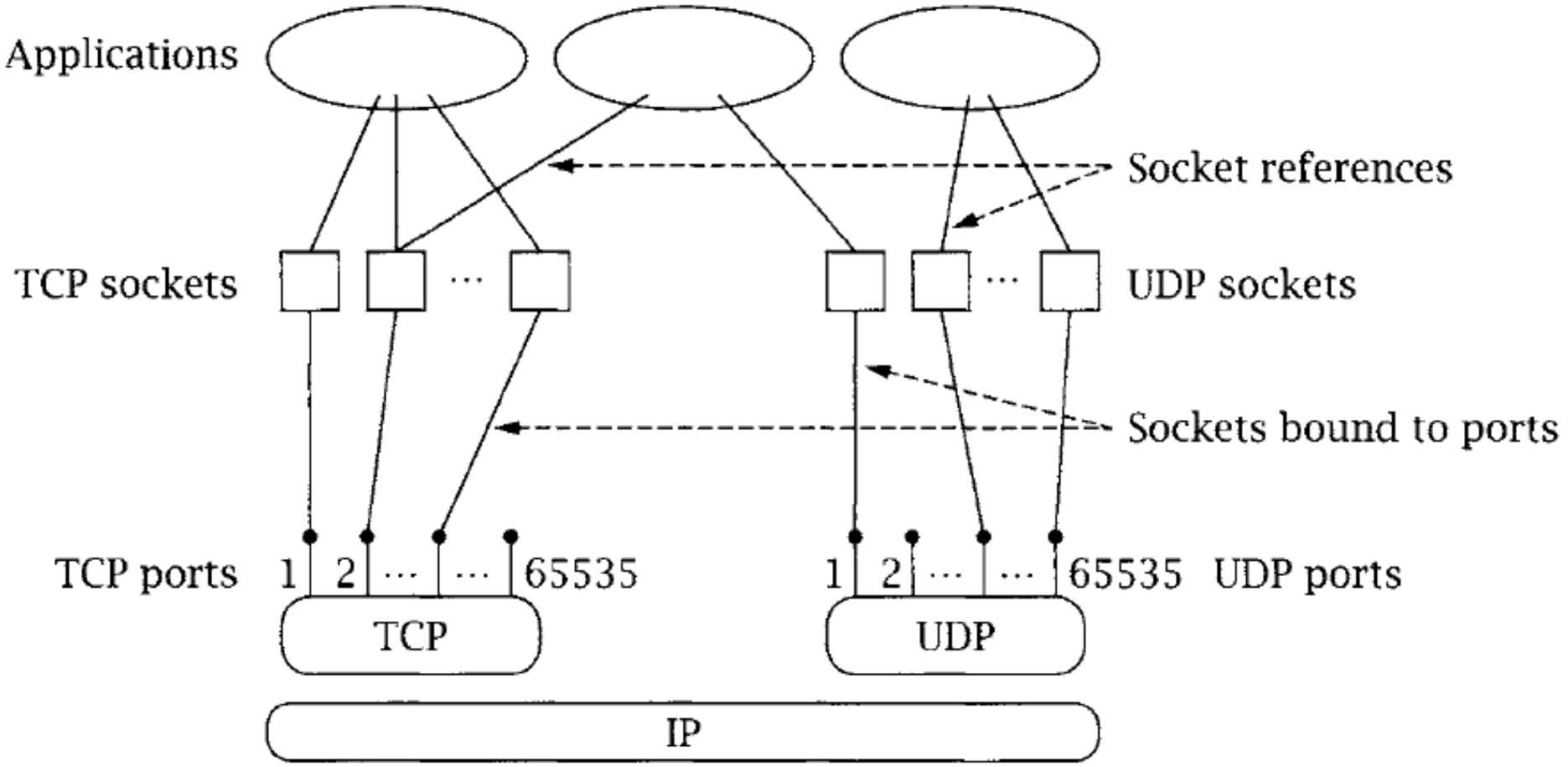








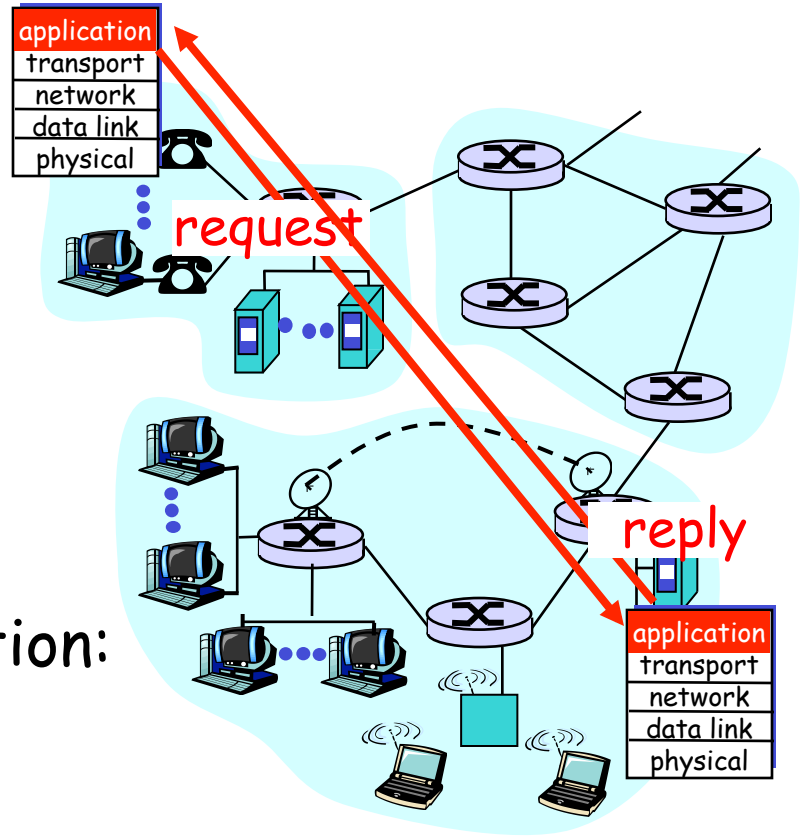
Multiplexing/Demultiplexing



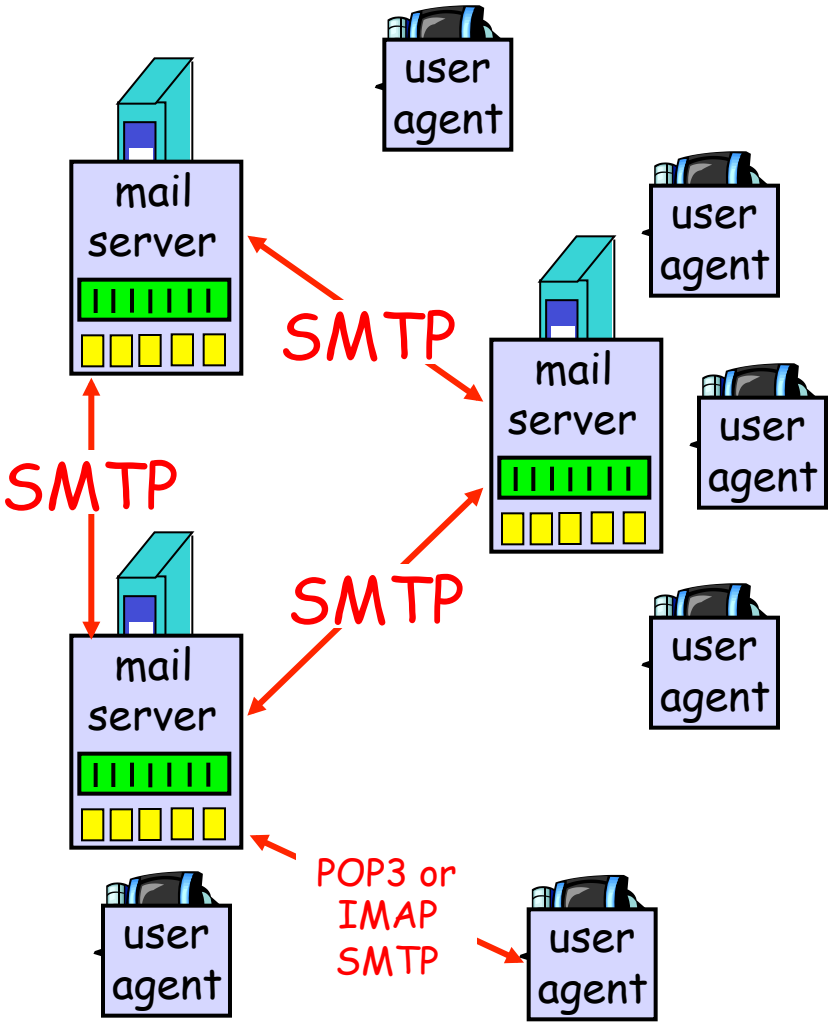
Recap: Client-Server Paradigm

- The basic paradigm of network applications is the client-server (C-S) paradigm

- Some key design questions to ask about a C-S application:
  - extensibility
  - scalability
  - robustness
  - security



Recap: Email App

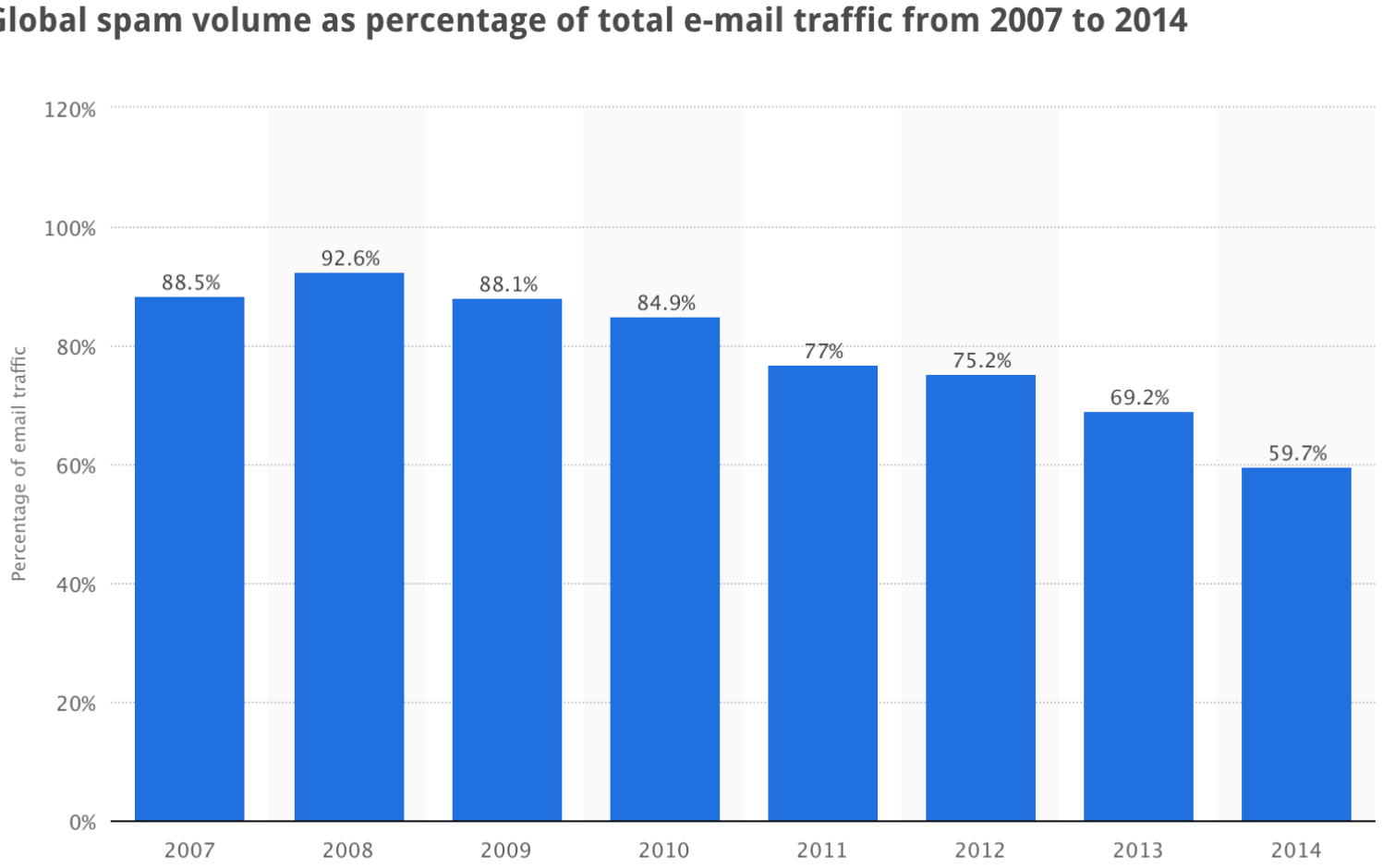


Some nice protocol extensibility design features

- separate protocols for different functions
- simple/basic (smtp) requests to implement basic control; fine-grain control through ASCII header and message body
- status code in response makes message easy to parse

Email: Challenge

- A large percentage of spam/phish



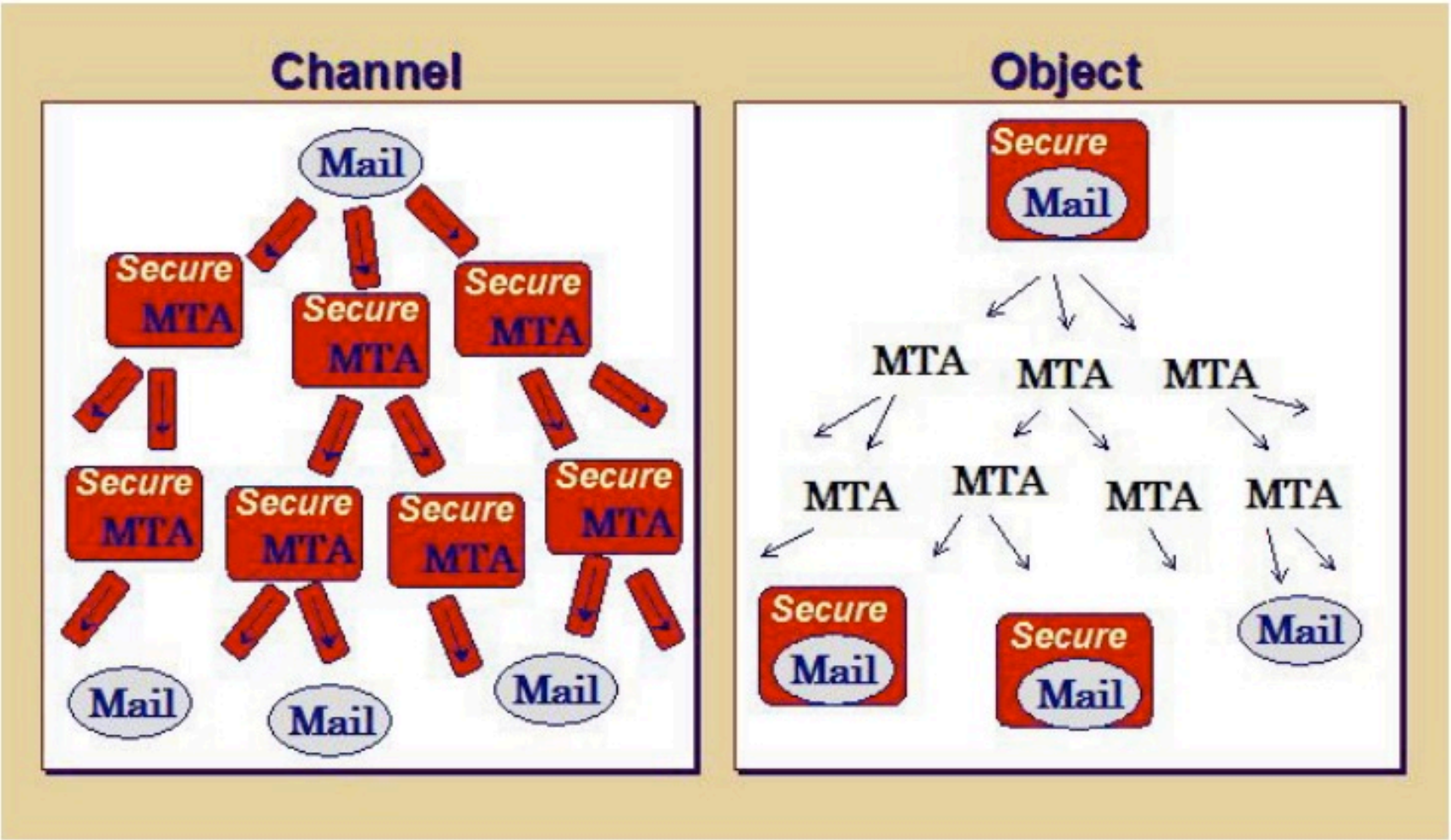
Source: http://www.statista.com/statistics/420400/spam-email-traffic-share-annual/

Recap: Spam Detection Methods by GMail

- Known phishing scams
- Message from unconfirmed sender identity
- Message you sent to Spam/similarity to suspicious messages
- Administrator-set policies
- Empty message content

https://support.google.com/mail/answer/1366858?hl=en

Current Email Authentication Approaches

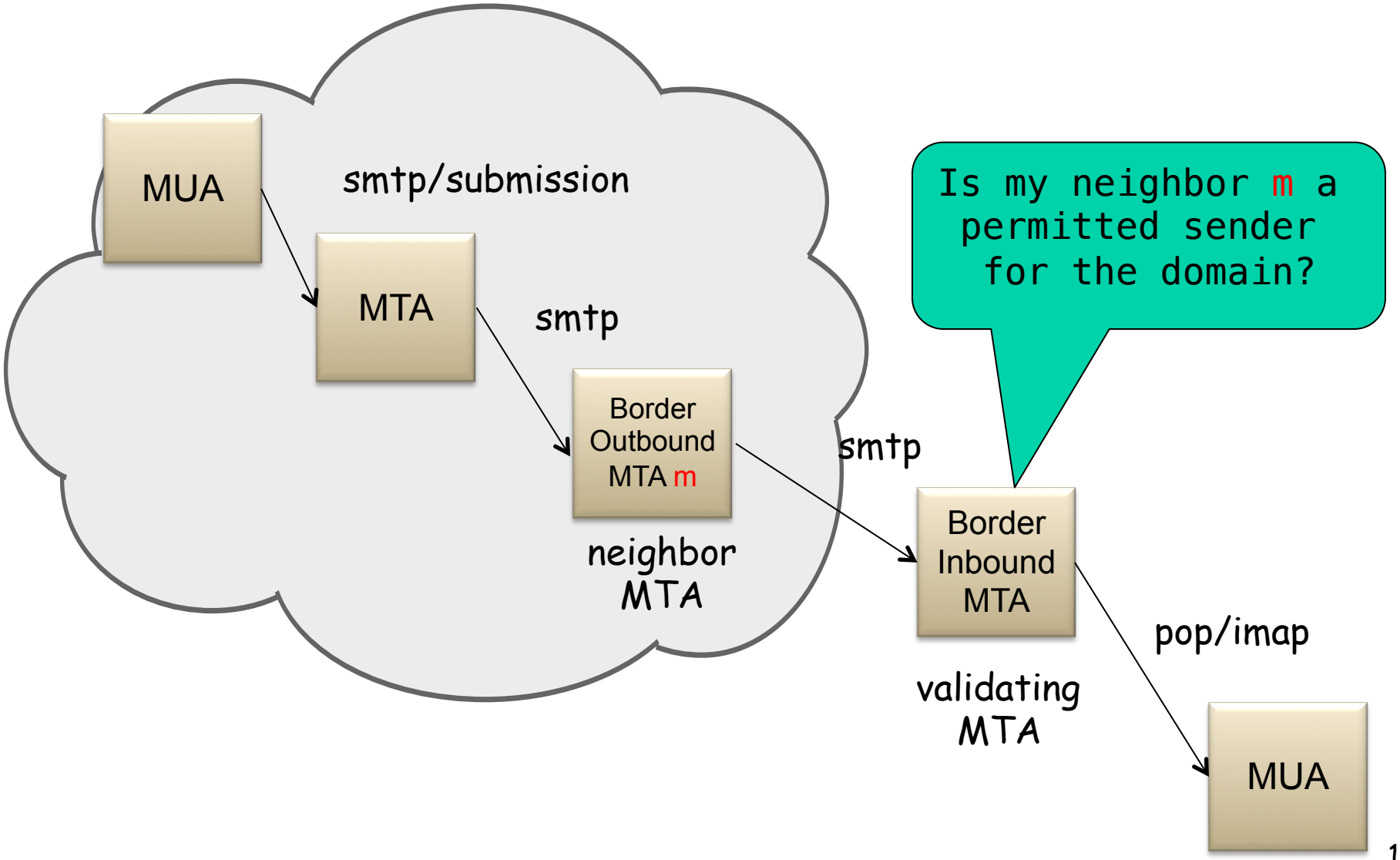


Sender Policy Frame (SPF)

DomainKeys Identified Mail (DKIM)

https://tools.ietf.org/html/rfc7208

Sender Policy Framework (SPF RFC7208)



SPF Exercise

- Test 1
  - Send real email by gmail
  - POP retr
- Test 2
  - Send using telnet
  - POP retr

Key Remaining Question for SPF?

- How does SPF know if its neighbor MTA is a permitted sender of the domain?

DomainKeys Identified Mail (DKIM; RFC 5585)

- A domain-level digital signature authentication framework for email, using public key crypto
  - E.g., gmail.com signs that the message is sent by gmail server
- Basic idea of public key signature
  - Owner has both public and private keys
  - Owner uses private key to sign a message to generate a signature
  - Others with public key can verify signature

Example: RSA

1. Choose two large prime numbers *p*, *q*. (e.g., 1024 bits each)

2. Compute *n* = *pq*, *z* = *(p-1)(q-1)*

3. Choose *e* (with *e* < *n*) that has no common factors with z. (*e*, *z* are "relatively prime").

4. Choose *d* such that *ed-1* is exactly divisible by *z*. (in other words: *ed* mod *z* = *1*).

5. *Public* key is *(n,e)*. *Private* key is *(n,d)*.

RSA: Signing/Verification

0. Given (n,e) and (n,d) as computed above

1. To sign message, m, compute h = hash(m), then sign with private key

   $s = h^d \bmod n$ (i.e., remainder when h^d is divided by n)

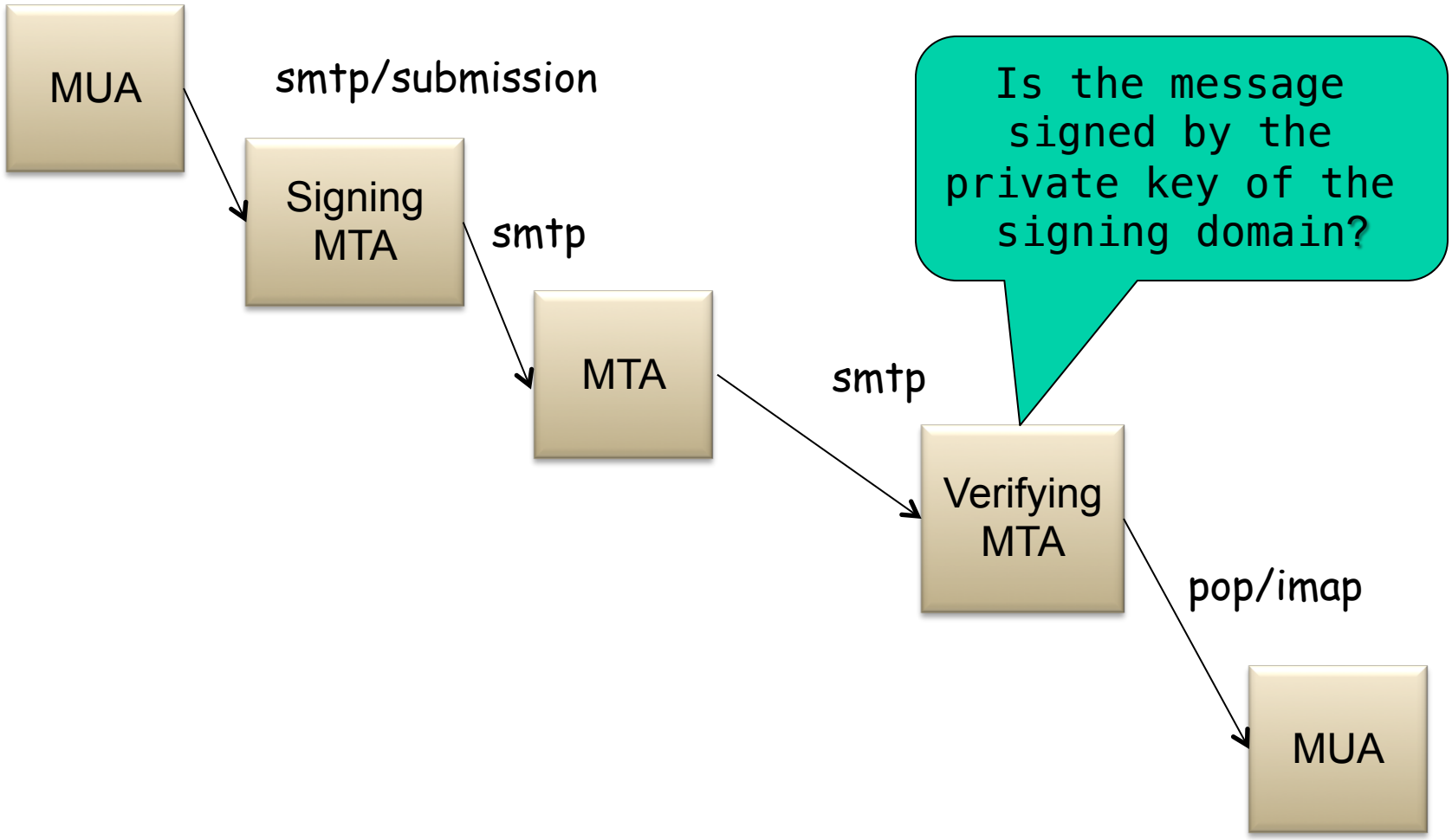
2. To verify signature s, compute

   $h' = s^e \bmod n$ (i.e., remainder when s^e is divided by n)

Magic happens! $h = (h^d \bmod n)^e \bmod n$

The magic is a simple application of Euler's generalization of Fermat's little theorem

DomainKeys Identified Mail (DKIM)



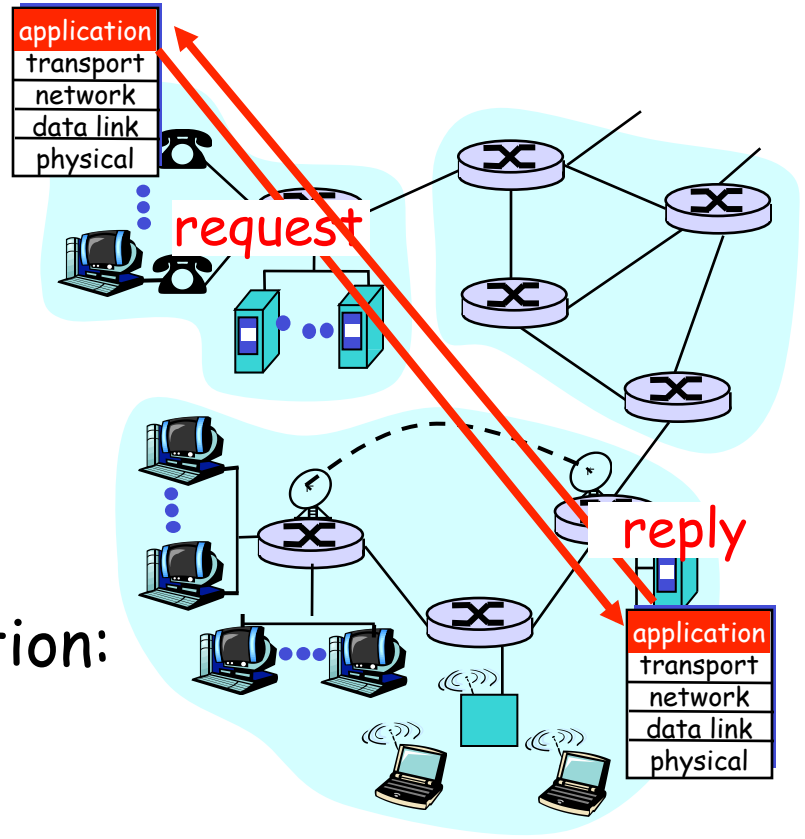
Key Remaining Question about DKIM?

- How does DKIM retrieve the public key of the author domain?

Summary: Client-Server Paradigm

- The basic paradigm of network applications is the client-server (C-S) paradigm

- Some key design questions to ask about a C-S application:
  - ✓ extensibility
  - ○ scalability
  - ○ robustness
  - ✓ security



Scalability/Robustness

- High scalability and robustness fundamentally require that multiple email servers serve the same email address

need an email server's IP address

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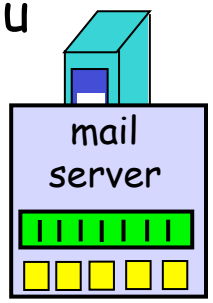

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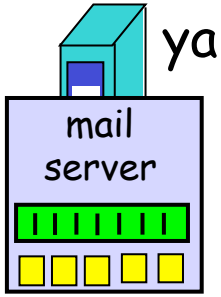

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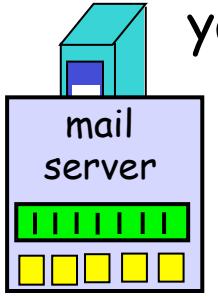

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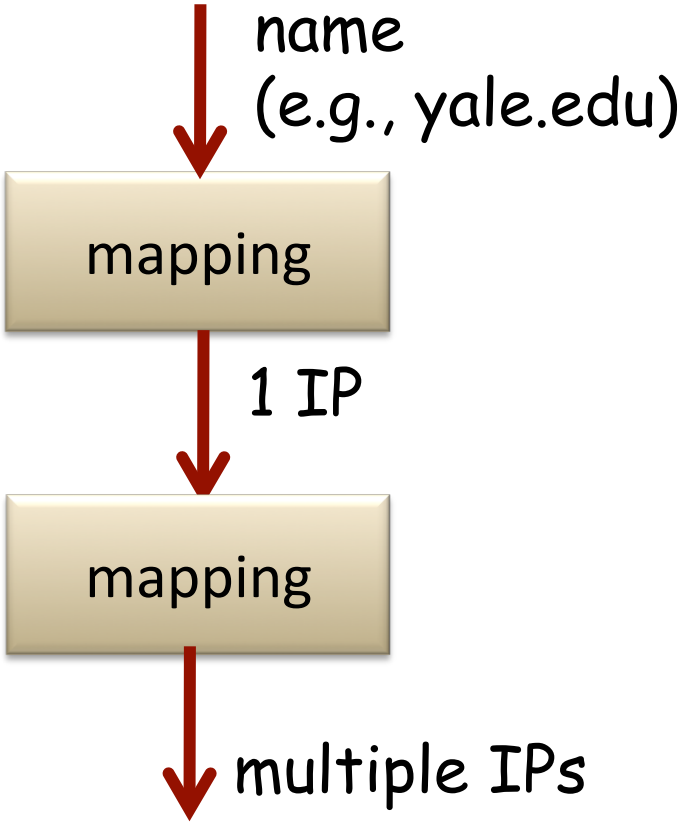
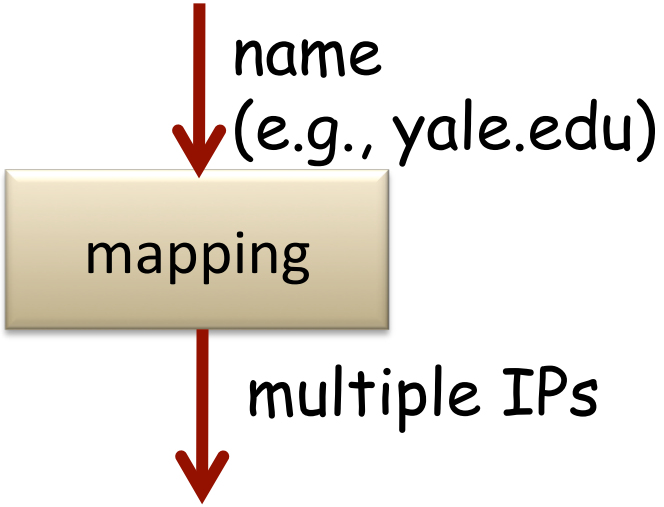
Mapping Functions Design Alternatives

- Map from an email address server name to IP address of email server





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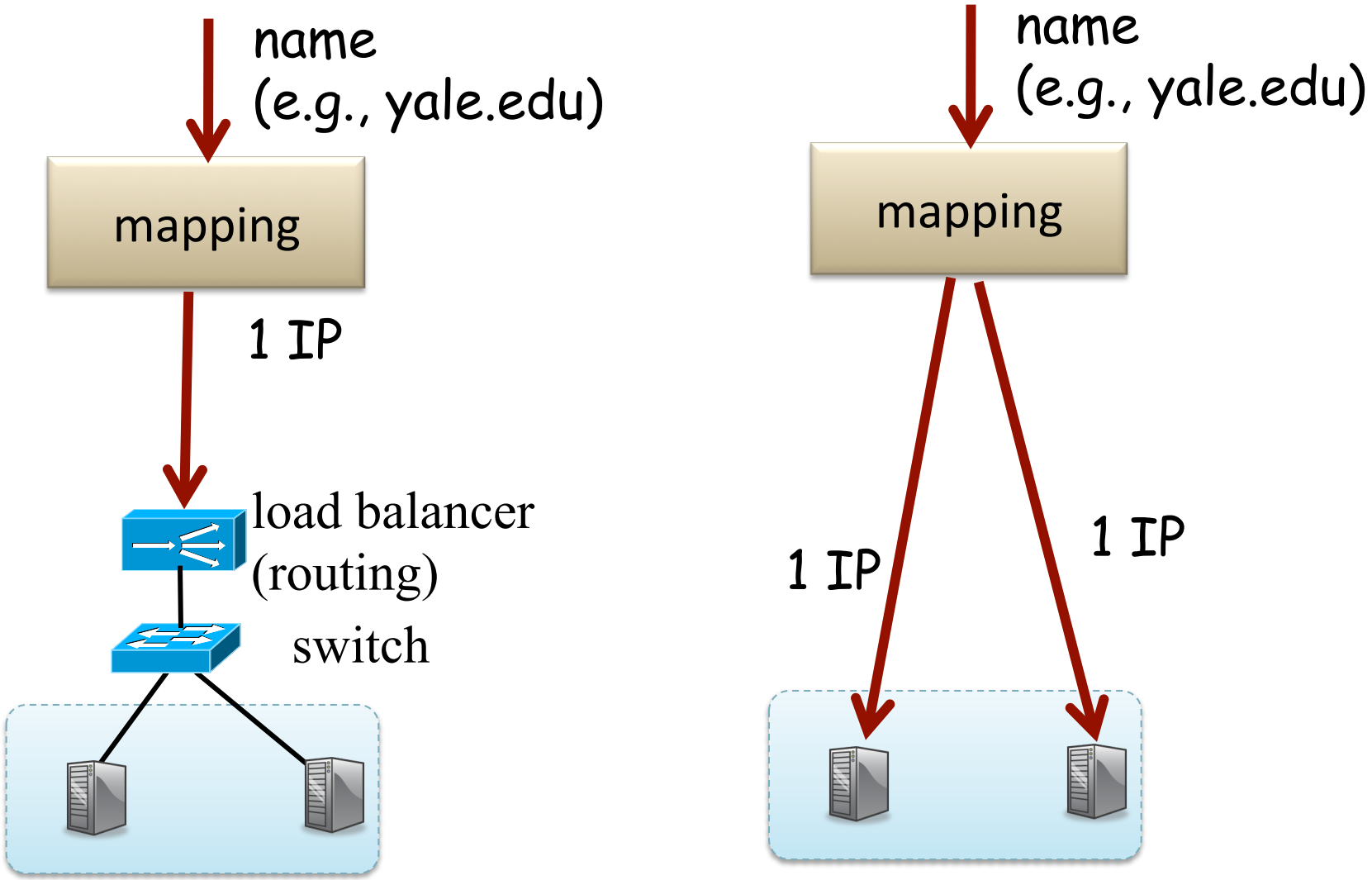


Summary: Some Key Remaining Issues about Email

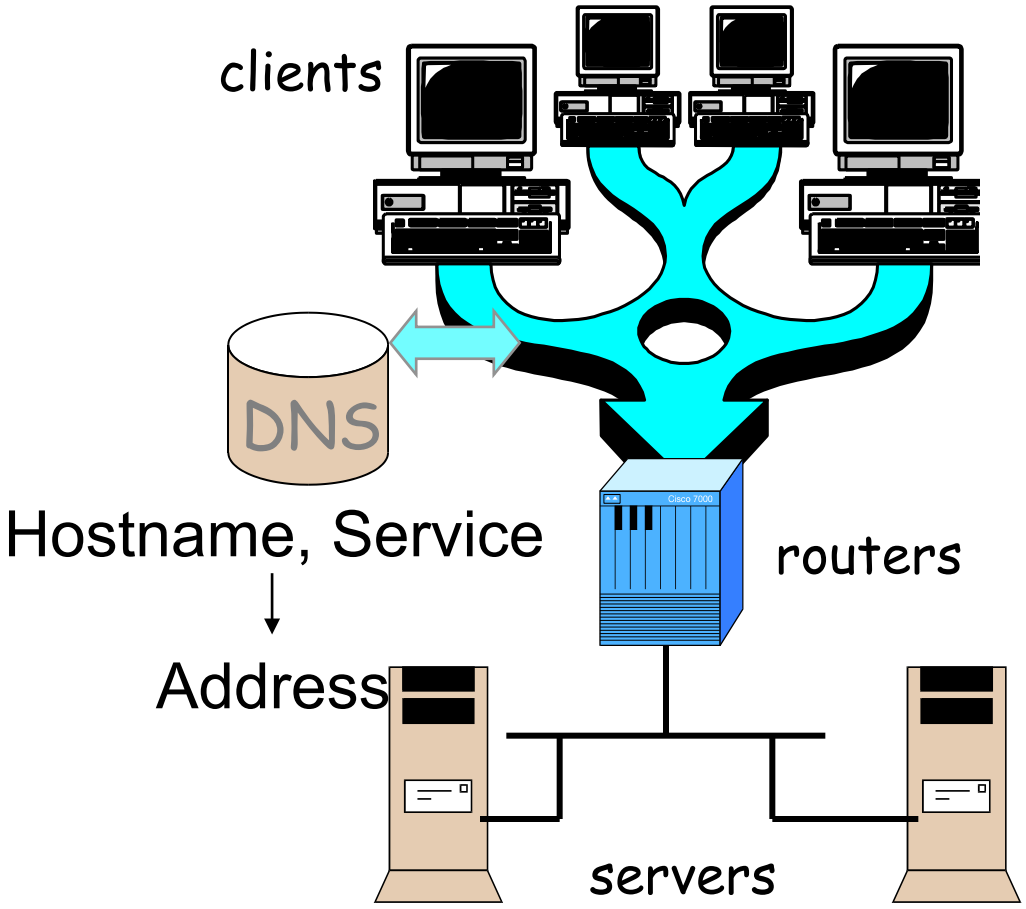
- Basic: How to find the email server of a domain?
- Scalability/robustness: how to find multiple servers for the email domain?
- Security
  - SPF: How does SPF know if its neighbor MTA is a permitted sender of the domain?
  - DKIM: How does DKIM retrieve the public key of the author domain?

Outline

- Recap
- Email security (authentication)
- DNS

DNS: Domain Name System

- Function
  - map between (domain name, service) to value, e.g.,
    - (www.cs.yale.edu, Addr) -> 128.36.229.30
    - (cs.yale.edu, Email) -> netra.cs.yale.edu



DNS Records

http://www.iana.org/assignments/dns-parameters/dns-parameters.xhtml

DNS: stores resource records (RR)

RR format: **(name, type, value, ttl)**

- Type=A
  - **name** is hostname
  - **value** is IP address
- Type=NS
  - **name** is domain (e.g. yale.edu)
  - **value** is the name of the authoritative name server for this domain
- Type=TXT
  - general txt
- Type=CNAME
  - **name** is an alias name for some "canonical" (the real) name
  - **value** is canonical name
- Type=MX
  - **value** is hostname of mail server associated with **name**
- Type=SRV
  - general extension for services

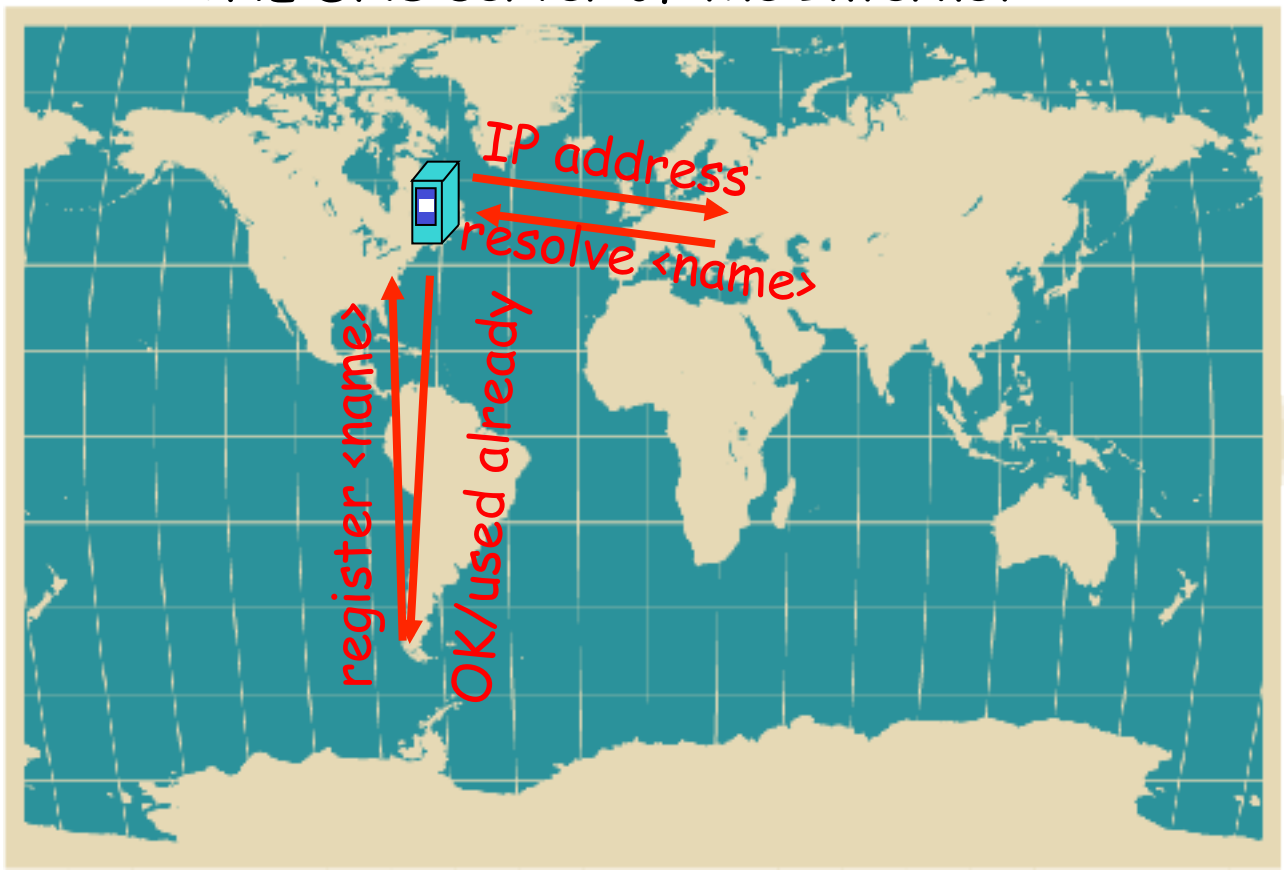
Try DNS: Examples

- dig <type> <domain>
  - type=MX
    - gmail.com
  - type=A
  - type=TXT
    - gmail.com
    - 20120113._domainkey.gmail.com

DNS Design: Dummy Design

- DNS itself can be considered as a client-server system as well
- How about a dummy design: introducing one super Internet DNS server?

THE DNS server of the Internet

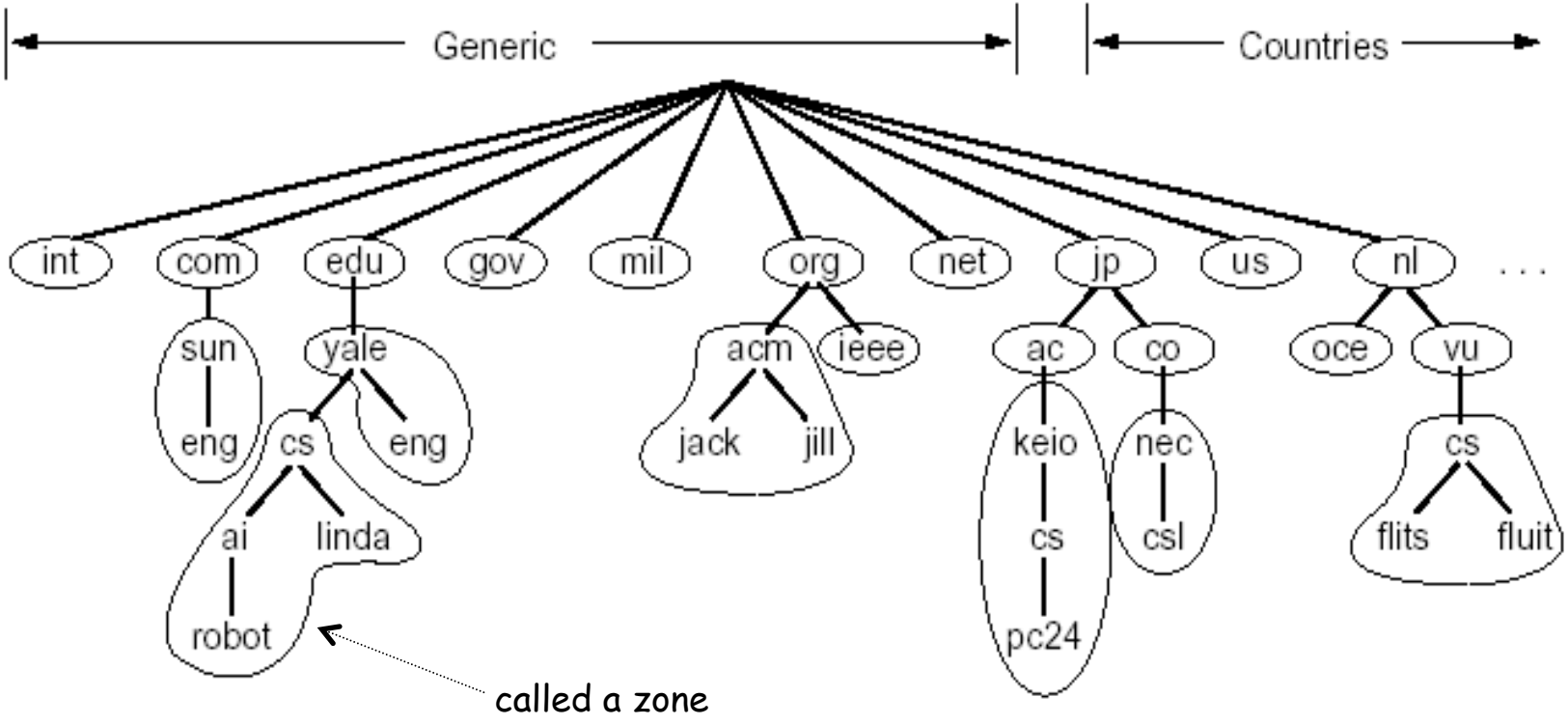


Problems of a Single DNS Server

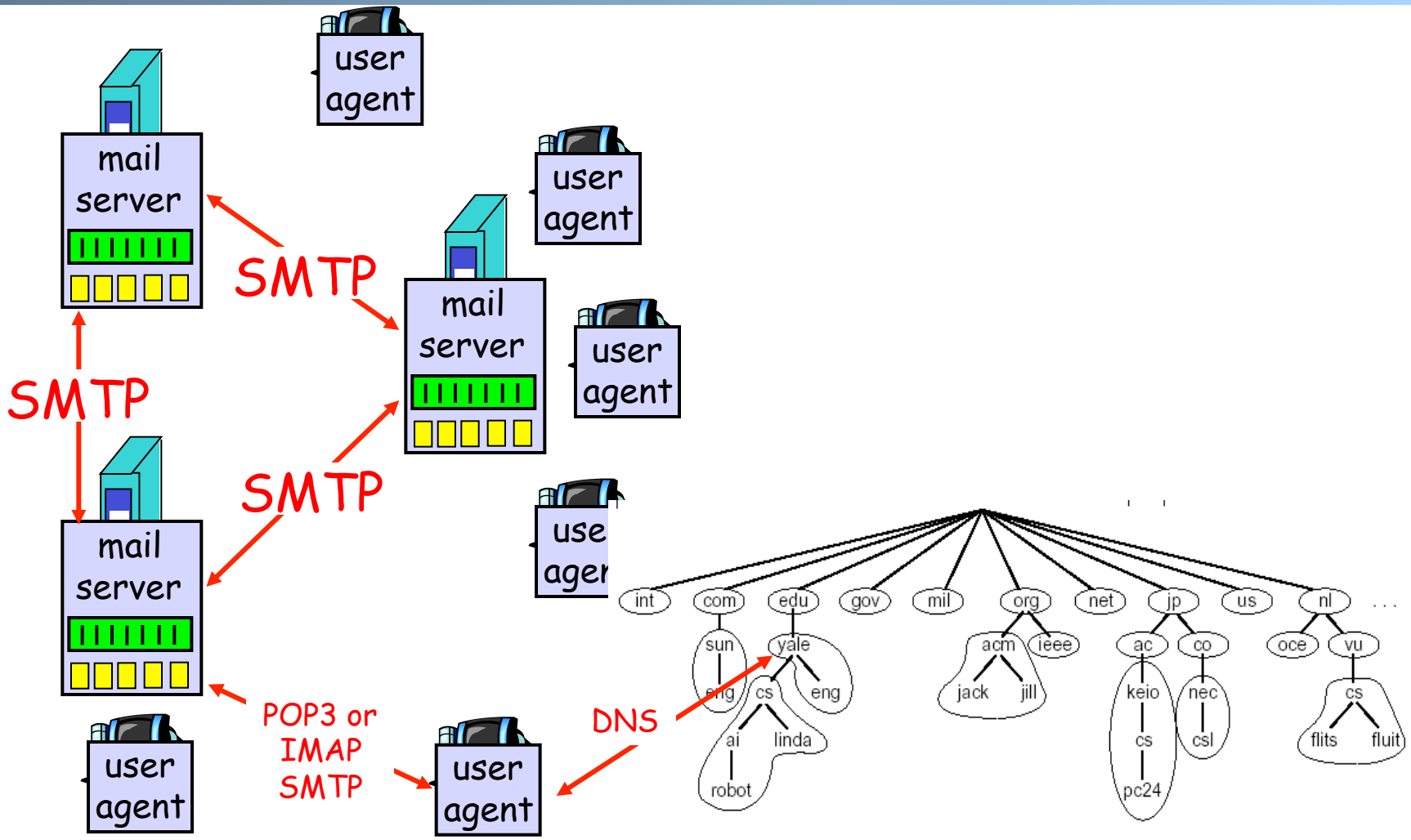
- Scalability and robustness bottleneck
- Administrative bottleneck

DNS: Distributed Management of the Domain Name Space

- A distributed database managed by authoritative name servers
  - divided into zones, where each zone is a sub-tree of the global tree
  - each zone has its own **authoritative name servers**
  - an authoritative name server of a zone may delegate a subset (i.e. a sub-tree) of its zone to another name server

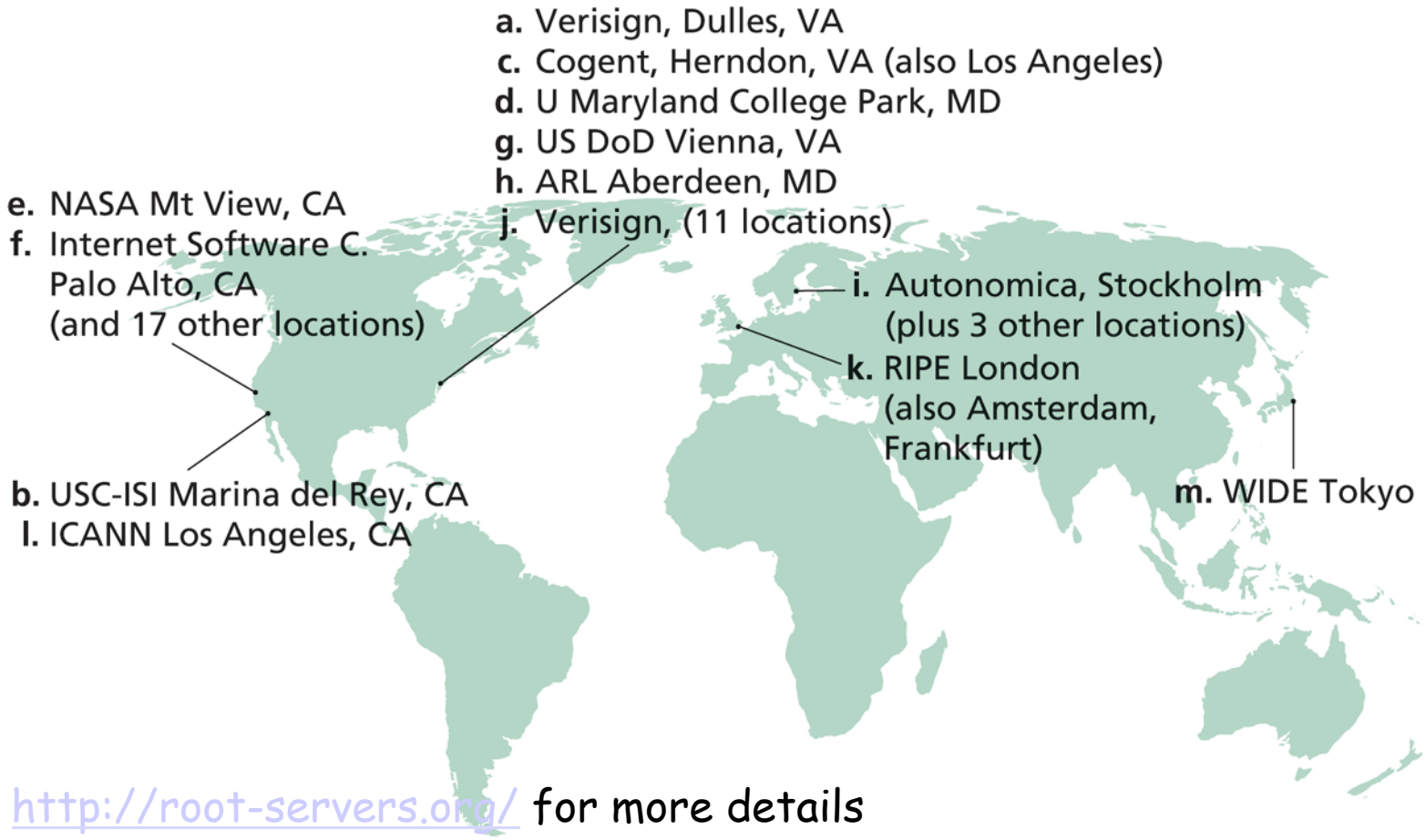


Email Architecture + DNS



Root Zone and Root Servers

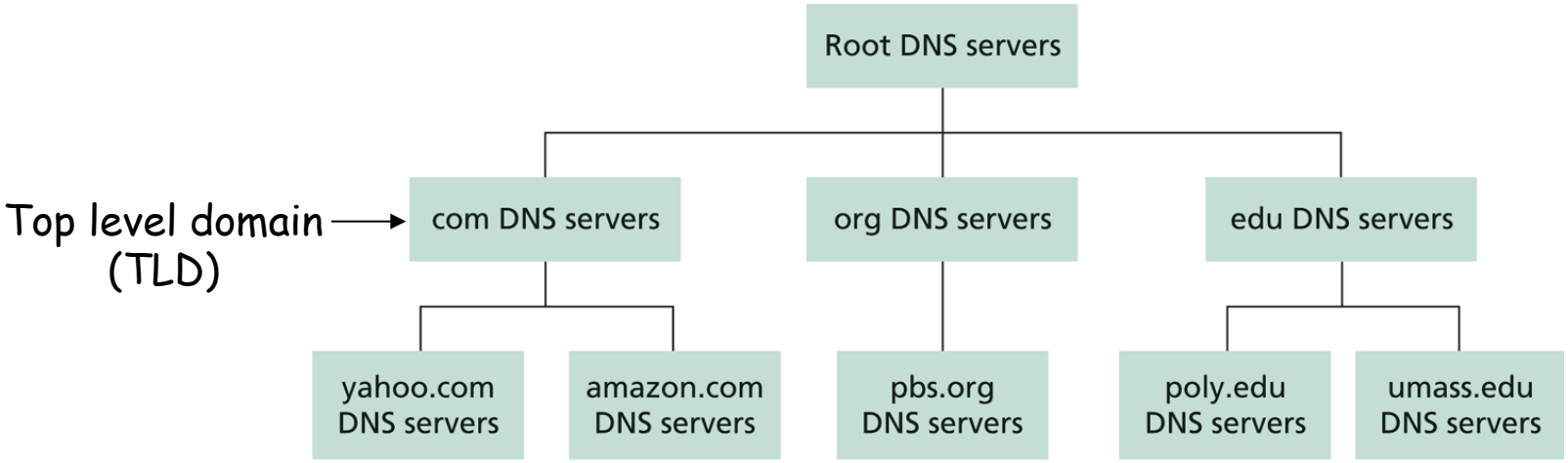
- The root zone is managed by the root name servers
  - 13 root name servers worldwide



See http://root-servers.org/ for more details

Linking the Name Servers

- Each name server knows the addresses of the root servers
- Each name server knows the addresses of its immediate children (i.e., those it delegates)



Q: how to query a hierarchy?

DNS Message Flow: Two Types of Queries

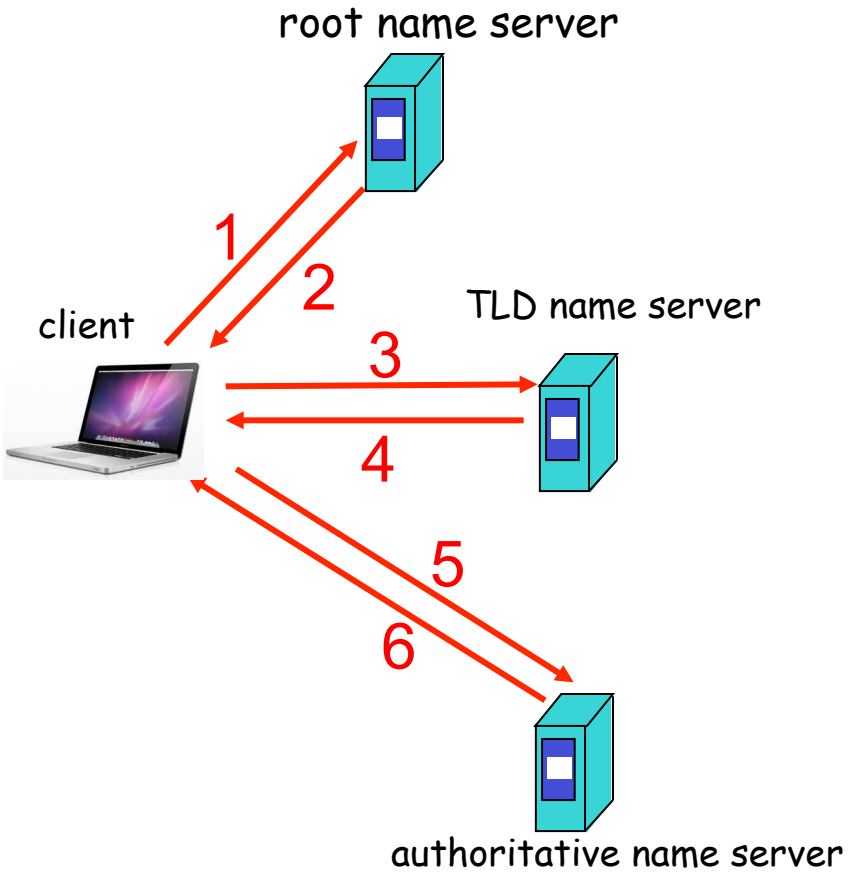
Recursive query:

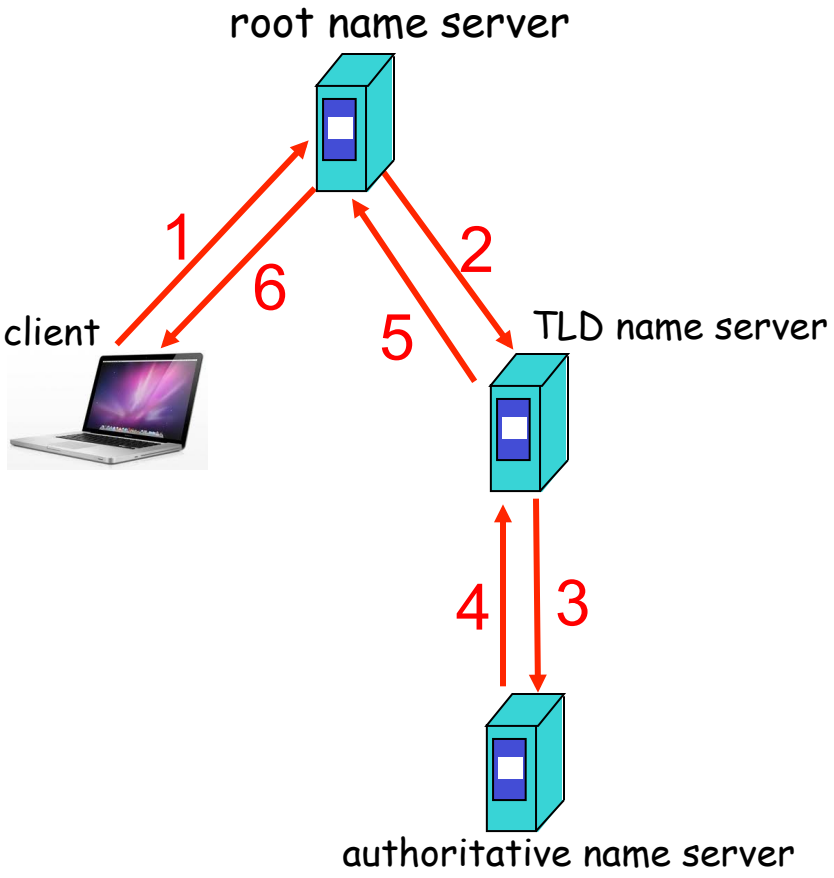
- The contacted name server resolves the name completely

Iterated query:

- Contacted server replies with name of server to contact
  - "I don't know this name, but ask this server"

Two Extreme DNS Message Flows



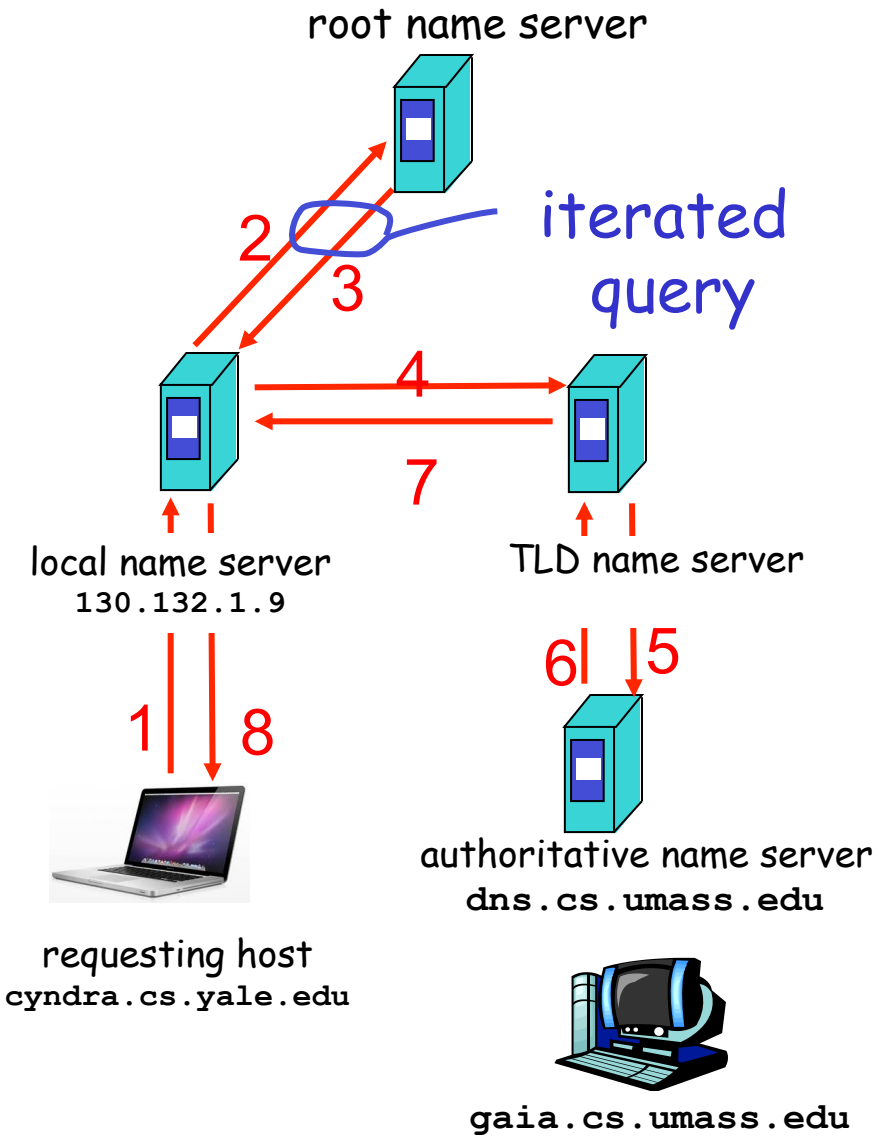


Issues of the two approaches?

cicada.cs.yale.edu

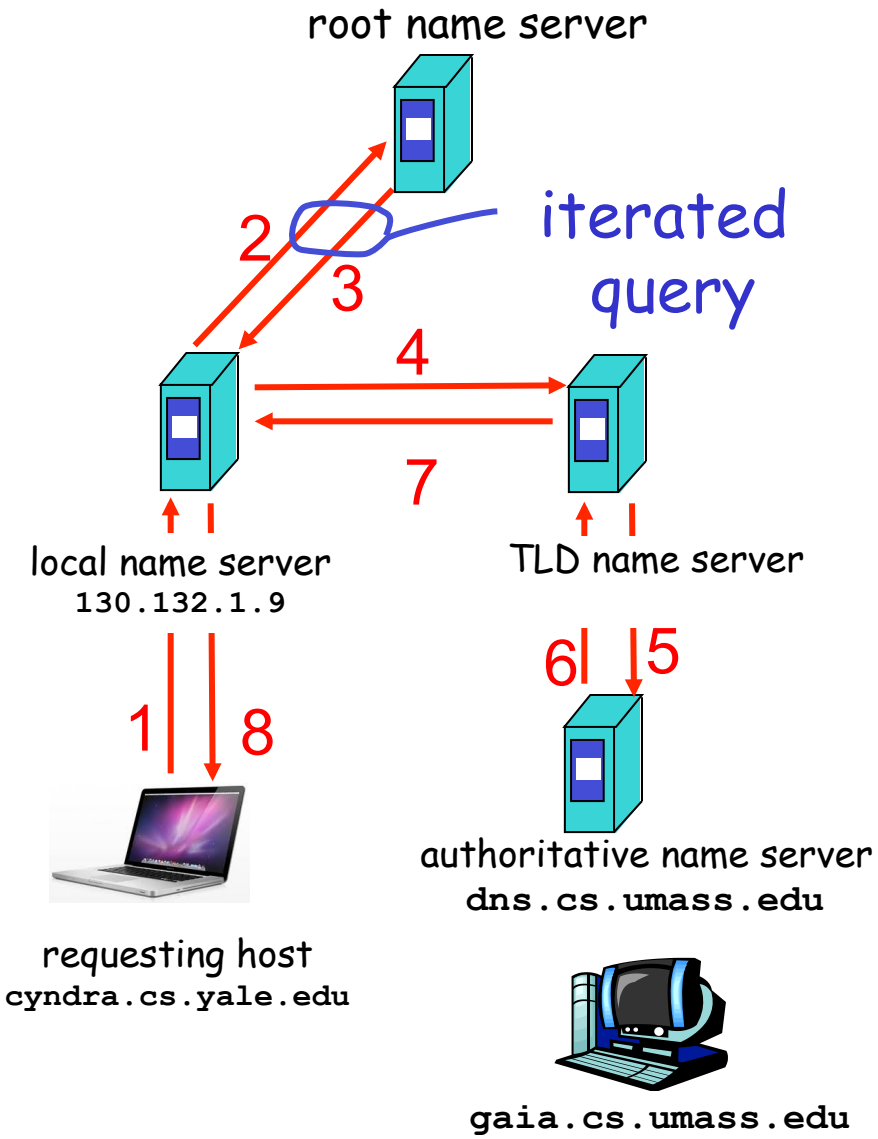
Typical DNS Message Flow: The Hybrid Case

- Host knows only local name server
- Local name server is learned from DHCP, or configured, e.g. /etc/resolv.conf
- Local DNS server helps clients resolve DNS names



Typical DNS Message Flow: The Hybrid Case

- Host knows only local name server
- Local name server is learned from DHCP, or configured, e.g. /etc/resolv.conf
- Local DNS server helps clients resolve DNS names
- Benefits of local name servers
  - simplifies client
  - Caches/reuses results



Outline

- Recap
- Email security (authentication)
- DNS
  - High-level design
  - Details

DNS Message Format?