

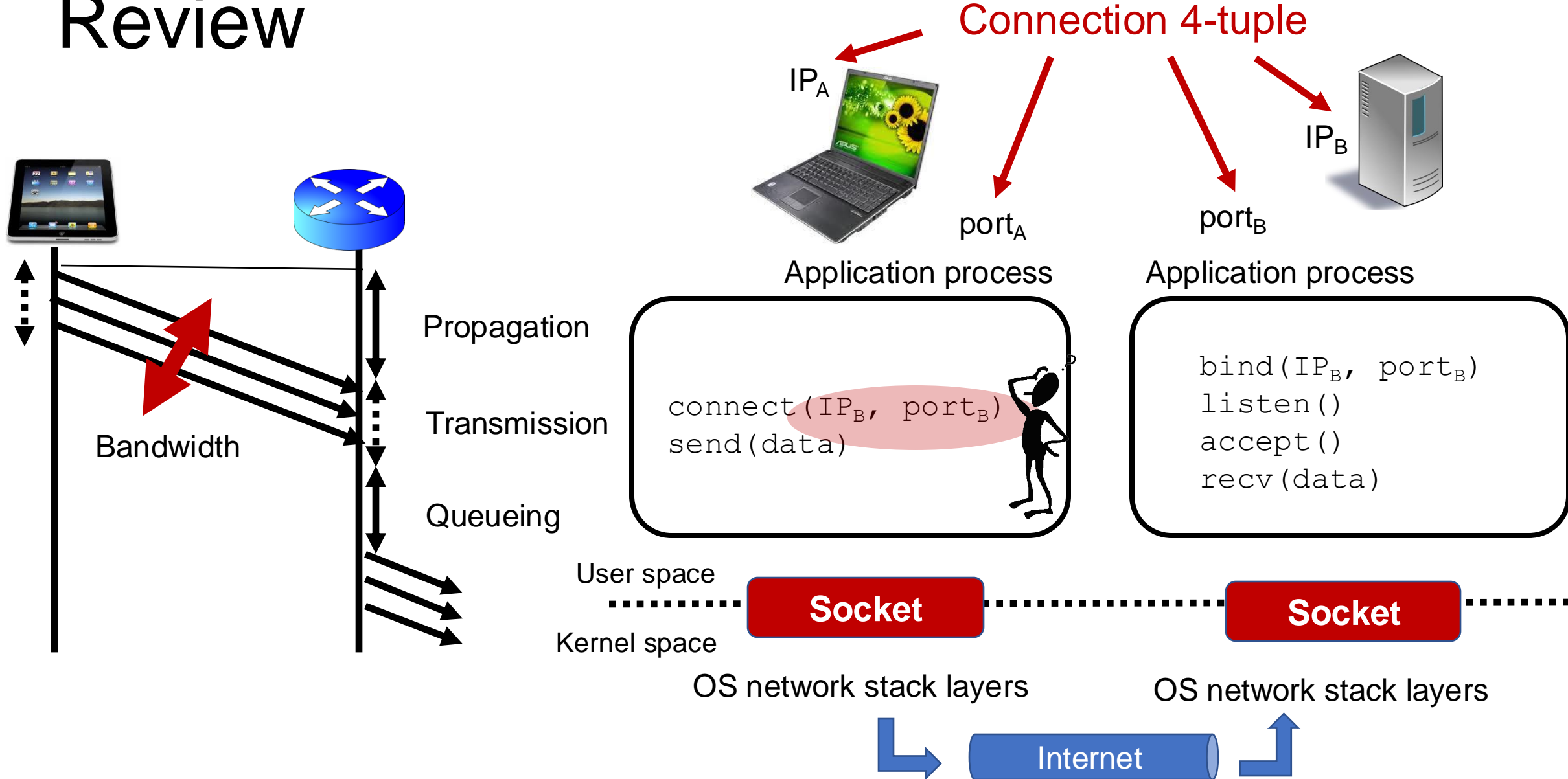
# Domain Name System

Lecture 4

<http://www.cs.rutgers.edu/~sn624/352-F24>

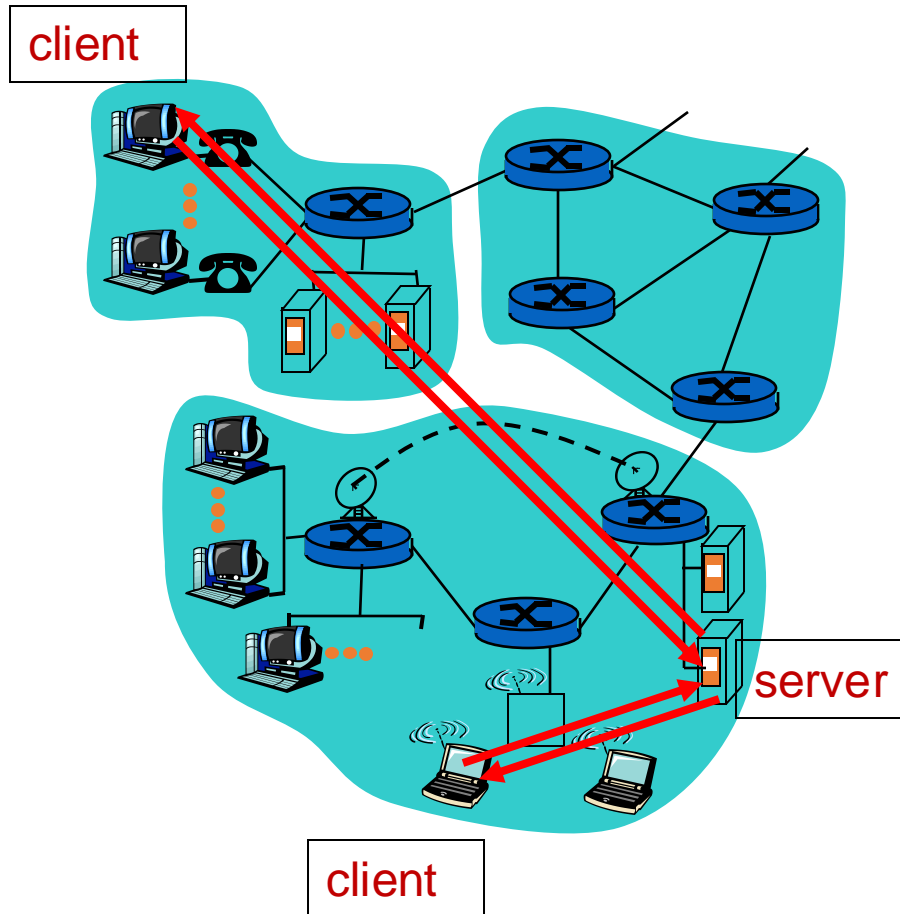
Srinivas Narayana

# Review



# Common Architectures of Applications

# Client-server architecture



## Server:

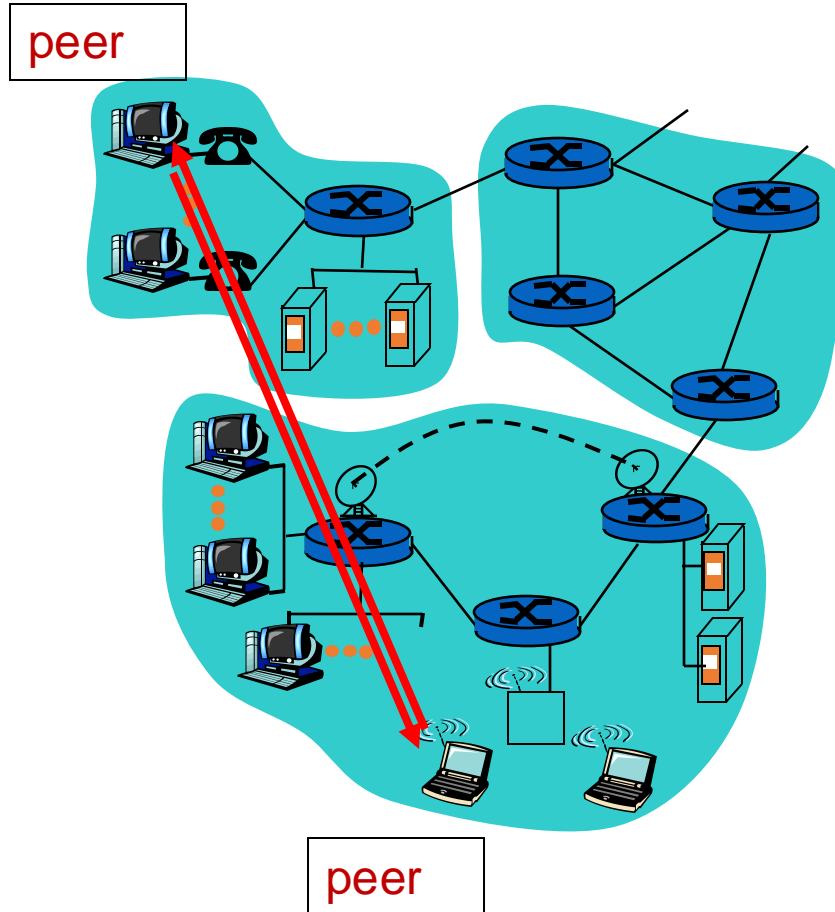
- Always-on endpoint
- Provides a “service” to the world
- Typically, a **permanent** IP address
- Hosted in clusters to scale to many users

## Clients:

- A “customer” of the service
- Maybe intermittently connected
- May have dynamic IP addresses
- Typically, do not communicate directly with other clients

- The web and most mobile apps use a client-server architecture

# Peer-to-peer (P2P) architecture



- **Peers:**
  - Intermittently connected hosts
  - Directly talking to each other
- Little to no reliance on always-up servers
  - Examples: BitTorrent
- Today, many applications use a **hybrid** model: servers to **set up** connectivity, communicate directly afterward
  - Example: (webRTC) Google meet

# Going forward: A few app-layer protocols

- Domain Name System
- The web
- Streaming video

# Domain Name System

# Domain Name System (DNS)

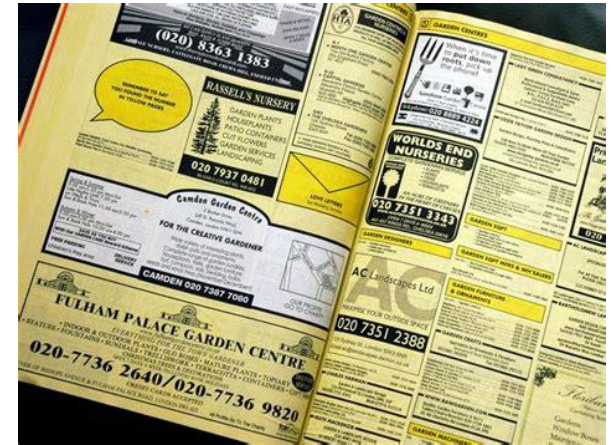
- Problem: Humans cannot remember Internet (IP) addresses
  - The average human brain can remember 7 digits for a few names
  - On average, IP addresses have 12 digits
- Solution: Use human-friendly names to refer to endpoints
  - Alphanumeric names (e.g. www.cs.rutgers.edu)
  - Called **host names** or **domain names**
- A new problem! We need a **directory (address book)** to translate human-friendly names to IPs



You have a name. Can you  
lookup an address?

# Directories

- Directories map a *name* to an *address*
- We call this process **Address Resolution**
- Simplistic designs
  - Central directory
  - Ask everyone (flooding)
  - Tell everyone (e.g., push to a file like /etc/hosts)
- Scalable distributed designs
  - Hierarchical namespace (e.g., Domain Name System (**DNS**))
  - Flat namespace (e.g., Distributed Hash Table)



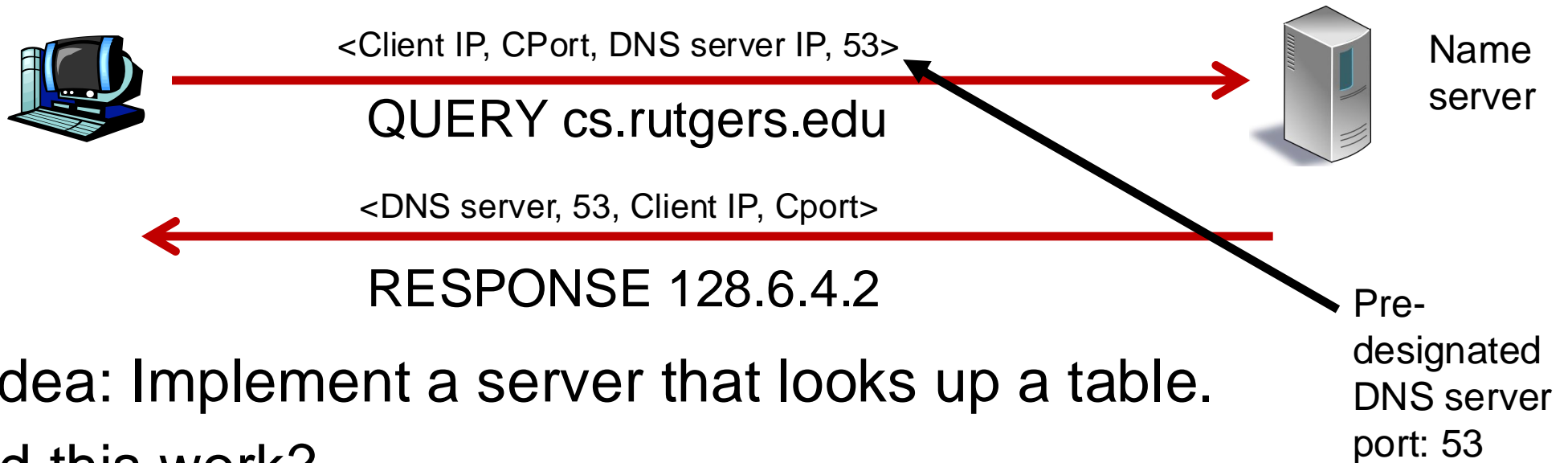
# Simple DNS (“tell everyone”)

- What if every endpoint has a local directory?
- /etc/hosts.txt: how DNS worked in the early days of the Internet
- Q: What if endpoints changed addresses? How do you keep this up to date?

nowski Maciej Czarn. Kraw. 911 610 41	Zakład Ubrze. Spółdzielczy s. Hauptanstalt f. Sozialversiche- rung	vollständiger Ks. Skrupka-Str 12 969 59	Zyminski 20 636 39	Grasynski 10 401 40	Spychalski Wil- helms. Skolost- 1
nowski Mieczysław R. 522 47	Sozialversicherungskasse in Warschau Weichselufer 33	Spallinski Mieczysław Salsko- kisch 1 740 59	Verkaufsbüro 321 02	Zucker-, Kautschuk-, Mineralöl- Konserven- u. Petroleum-Refe- rals 448 05	Spys Jan Nap- fah. techn. Hand- skunst 1
nowski Stanisław R. 415 65	Deutscher Kommissar 240 66	Spallenstein Franciszek Ind- ustr 9 927 27	Werkleiter Büro Sekretärin 10 17 15	Baumfeller Grasynski 22 418 39	Srebrny Kazimi- lusz 16
nowski Stanisław Medani- er Radeholstr 2 596 78	Stellvert. d. Deutschen Kommi- ssars 346 48	Sparkasse s. unter Kassel Blumestr 4 323 02	Wohnung 10 17 15	Gesamtschiff. Korrespondenz- kurse Wiktorstr 16 434 45	Srednicka Wlad Korsettmacherin f
nowski Stanisław Desin- dt. Baumstr. Siemestr 45 599 82	Drehtisch Chefart 628 95	Sparterie Holzindustrie GmbH Madalinskistr 87 422 02	Stellvertreter d. Werksleiter Büro 10 60 22	Leiter u. Büro 427 24	Srednicki Dr. M we Kolost 10
nowski Stanisław Dr. med. 826 08	Hausverwaltung 686 99	Spasinska Jadwiga Rakowic- kistr 3 425 35	Wohnung 10 60 22	Verkaufsbüro, Verk. v. Sacha- ten u. Kontingentart. f. d. Kreis Warschau 427 14	Srednicki Broni Loki Wielkistr 1
nowski Szymon Verlelung- alle Santa Potanska Ecke Mech- schistr 673 03	Zentrale Anal. Laborat. Sonn- u. Feiertage 11—12 558 04	Spasowicz Eugeniusz 6 Sier- piemstr 24 944 47	Hauptkassierin Ausland 10 07 06	Ref. Kontingentart. f. d. Stadt Warschau 407 54	Srednicki Stan- Kieferarzt Targos
nowski Tadeusz Leutner- w Pus-XI-Str 13 936 45	Wirtschaftslager Dorfstr 20 805 13	Spanowiczowa Aniela + Be- amin Rodarskistr 26 238 95	Personalbüro Leiter 10 14 69	Lager Grasynski 13 439 68	Srednicki Stanis- Kieferarzt Targos
nowski W. Eisenwarenver- k. 8 614 03	Schreibmat-Lager Polnistr 34 992 62	Spaw Stahlkonstruktionswerk Kwiecinski Wl. Traktykistr 17 321 49	Büro d. Techn. Abt. 10 02 77	Litzmannstr 84 291 88	Srednicki Stanis- str 52
nowski W. Elsenw. Verk. Hahnenallee 12a 436 06	Druckerei Litmannstr 39 627 56	Spech Elzbieta Karstr 108 10 23 49	Mechanische Werkstätte 10 43 49	Kolejowstr 5 334 44	Srednicki Leon str 24
nowski Wladislaw + Nordd- lee 180 442 17	Landgut Grotz Weichselufer 35 558 01	Spech Willi Ingenieurbauteile Märzstr 6 900 89	Aht. Haushaltung Leiter Büro 10 14 81	Whech 11 Lastopstr 21 684 34	Sroczyńska Apo- str 20
nowski Edzislav & Co. arschauer Mühlabstr 8s. Mac- swic-Str 3/5 10 30 53	Reise Flotter Intendant 558 02	Spech Paula Weis. u. Spiritus- schidig Neuwelt 3 805 72	Verkaufsbüro 10 31 89	Zweigstelle f. Schreibwaren- del Romanstr 8/10 413 97	Sroczyńska Apo- str 20
nowski Eymont Ing. Mo- swastr 41 832 44	Garage 558 03	Spech Transporthörs Pöhl 9 338 00	Verkaufsbüro 10 26 25	Hahnstr 196 900 15	Sroczyńska Apo- str 20
nowski E. u. Wojciechowski f. Bauung. GmbH Krucstr 8 881 84	I. Bezirk Smulikowstr 1/3 Zentrale * 558 00	Spier Gertrud Verk. u. Spirit. u. Ordnestr 19 805 72	Aht. Brandwehreinsparung 10 16 77	Büro Hahnstr 204 717 25	Sroczyńska Apo- str 20
nowski Henryk Ing. Bormo- Parkowstr 7 11 17 14	II. Bezirk Polnistr 34 Oberamt 932 84	Spiedt Transporthörs Pöhl 9 338 00	Fabrik Laboratorium 10 16 77	Tuben u. Brückenmacher- Düster- 48	Sroczyńska Apo- str 20
nowski Adam Dr. med. f. innere Med. Hahnstr 43 979 69	Vertrauensstelle 746 47	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Büro 11 06 82	Sroczyńska Apo- str 20
nowski Stanislaw Hahnstr- d. Bldg. f. Markthalle 10 509 47	Büroleiter u. Sekretariat 830 71	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20
nowski Eugenien Widostr 23 645 98	Meldebüro u. Intendant 836 57	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20
nowski Alfons Feldherrn- str 117a 436 62	Referat d. Krankheitswesen 822 06	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20
nowski Jan Seilerw. Bormo- str 12 636 65	Referat d. Krankheitswesen 822 06	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20
nowski Janusz Elsenw. Bormo- str 12 636 65	Referat d. Krankheitswesen 822 06	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20
nowski Adam Ing. Mech. R. Hahnstr 45 431 48	Referat d. Krankheitswesen 822 06	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20
nowski S. Marschalstr 15 926 80	Referat d. Krankheitswesen 822 06	Spiedt Transporthörs Pöhl 9 338 00	Rechnungs- u. Abrechnung Leiter 10 06 48	Rechnungs- u. Abrechnung Leiter 11 09 79	Sroczyńska Apo- str 20

# Simple DNS

DOMAIN NAME	IP ADDRESS
spotify.com	98.138.253.109
cs.rutgers.edu	128.6.4.2
www.google.com	74.125.225.243
www.princeton.edu	128.112.132.86



- Key idea: Implement a server that looks up a table.
- Would this work?
  - Every new (changed) host needs to be entered in this table
  - Performance: can the server serve billions of Internet users
  - Failure: what if the server or the database crashes?
  - How to secure this server?

# Ideas to make DNS work for the Internet

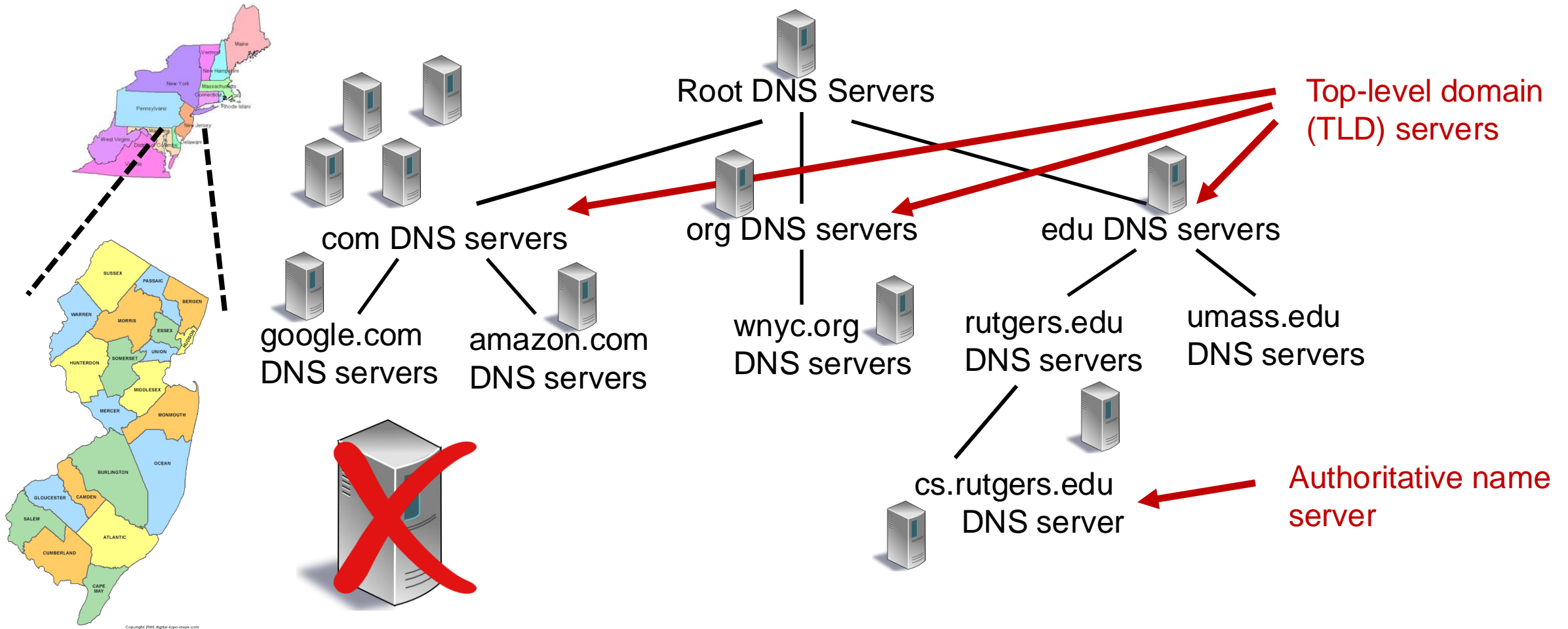
- Idea #1. Hierarchy

- Organize names hierarchically so we can divide the work of resolution
- Internet: some names under “.com”, others with “.org”, “.edu”, ...
- Called top-level domains (TLD)
- TLDs may contain sub-domains, sub-sub-domains, ...
- Lowest level: fully qualified domain name (e.g. people.cs.rutgers.edu)

- Idea #2. Distribution

- Each node in the hierarchy served separately (name servers)
- Lowest level: Manage changes in IP addresses of endpoints
  - Authoritative name server

# Distributed and Hierarchical database



RFC 1034

Hierarchy

Replication

# DNS Protocol

- Client-server application
- Client connects to (known) port 53 on server
- For now, assume the DNS server IP is known
- Two types of messages
  - Queries
  - Responses
- Type of Query (OPCODE)
  - Standard query (0x0)
    - e.g., Request IP address for a given domain name
  - Updates (0x5)
    - Provide a binding of IP address to domain name

# DNS in action

- `dig <domain-name>`
- `dig +trace <domain-name>`
- `dig @<dns-server> <domain-name>`
- Don't just watch; try it!

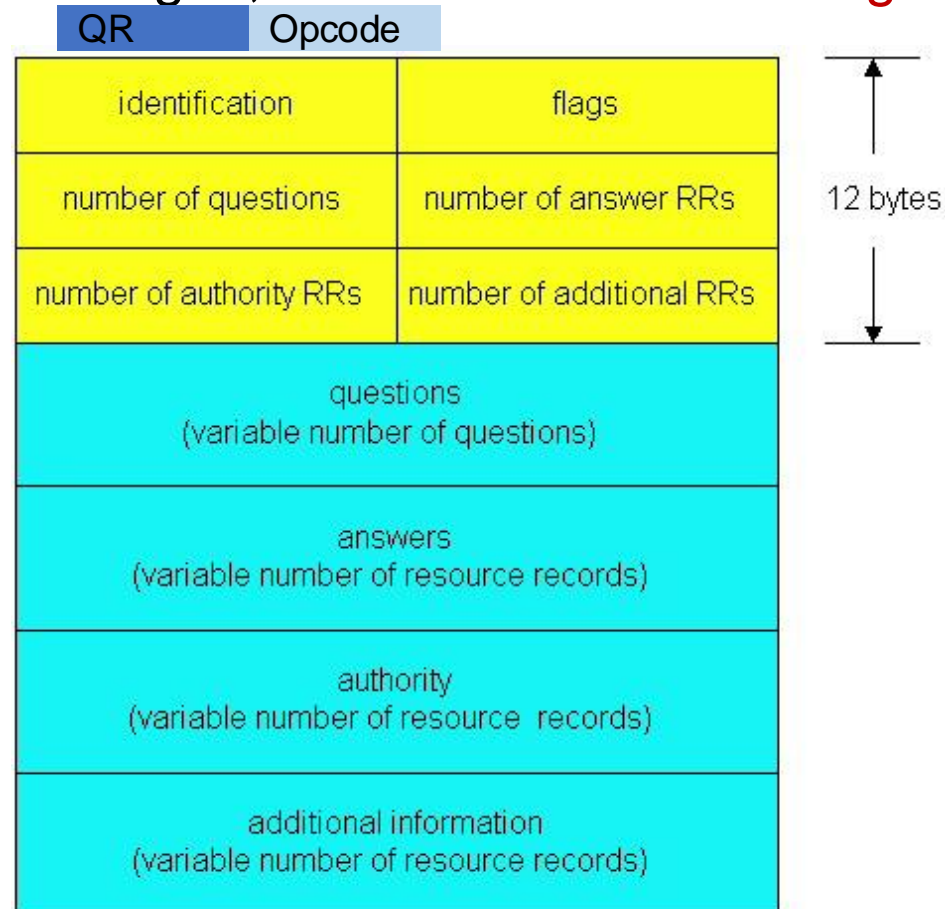


# DNS protocol: Message format

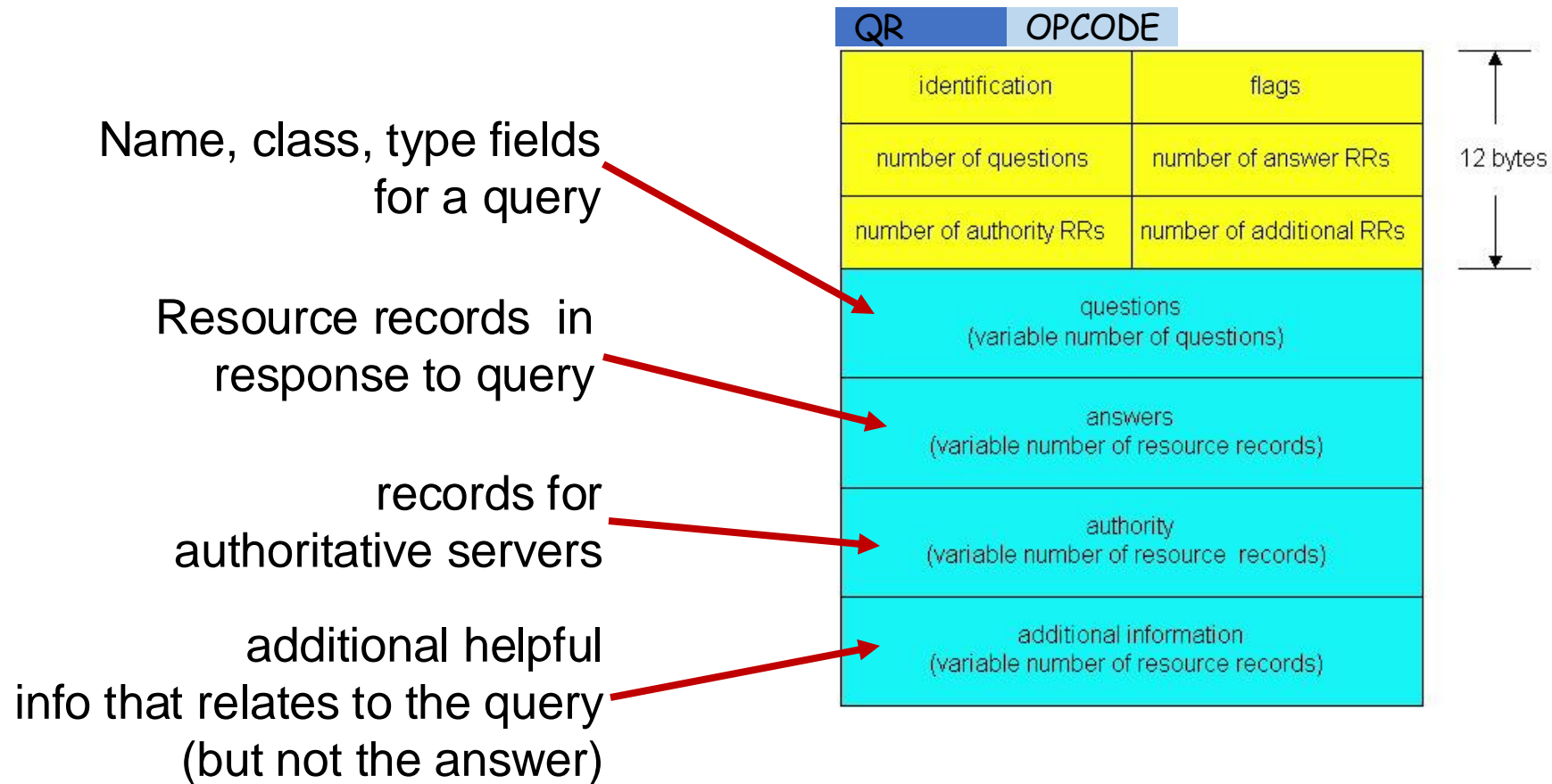
DNS protocol: query and reply messages, both with same message format

## Message header

- QR = 0 for Query, 1 for response
- Opcode= 0 standard
- identification: 16 bit # for query, reply to query uses same #
- flags:
  - Authoritative answer
  - recursion desired
  - recursion available
  - reply is authoritative



# DNS protocol: Message format



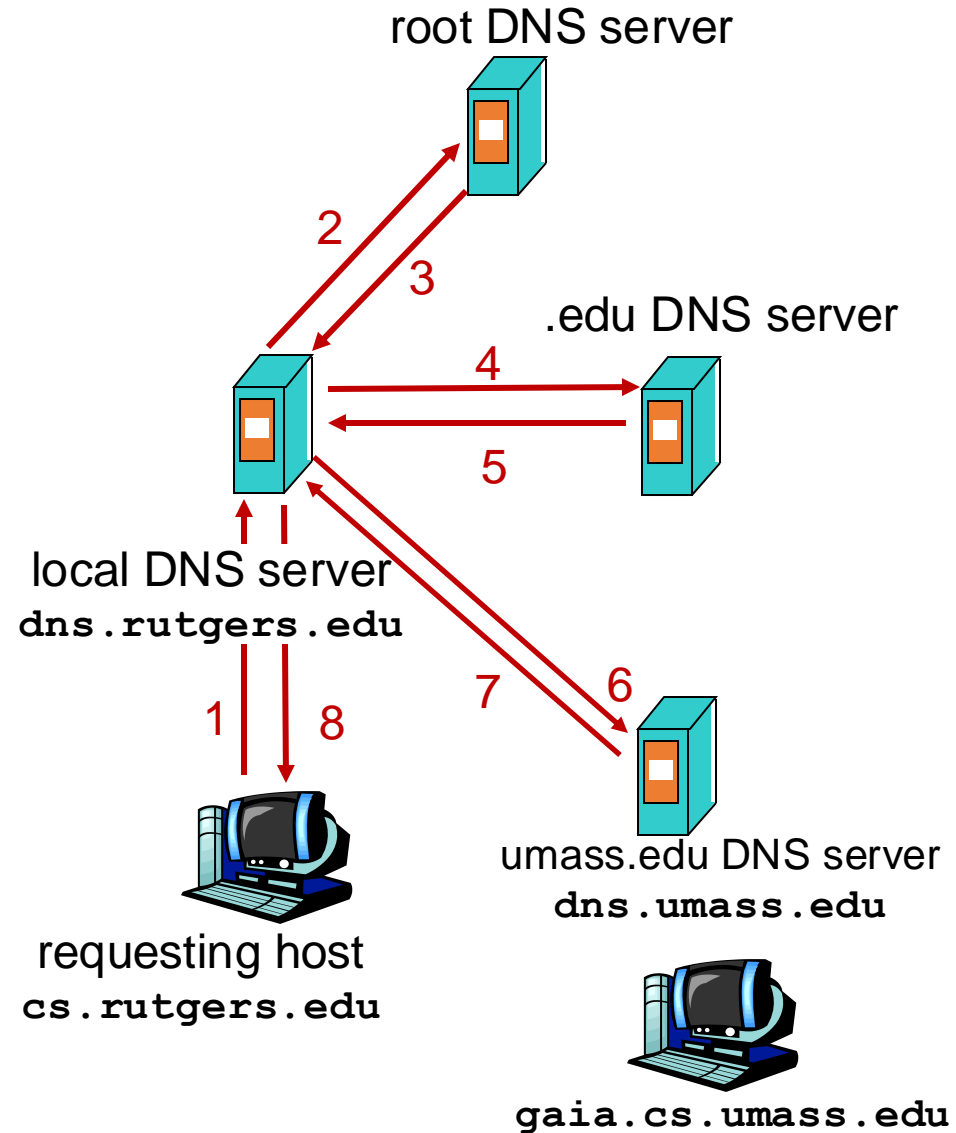
# DNS Protocol: Actions

- When client wants to know an IP address for a host name
  - Client sends a DNS query to the “local” name server in its network
  - If name server contains the mapping, it returns the IP address to the client
  - Otherwise, the name server forwards the request to the root name server
  - The request works its way down the DNS hierarchy until it reaches a name server with a mapping for the requested name



# Example

- Host at cs.rutgers.edu wants IP address for gaia.cs.umass.edu
- Local DNS server
- Root DNS server
- TLD DNS server
- **Authoritative** DNS server



# Query type

- Iterative query
- Contacted server replies with name of server to contact
- “I don’t know this name, but ask this other server”
- Queries 2,4,6 are iterative from point of view of the local DNS server

