Peer-to-Peer Networks

Chapter 1: Introduction

Thorsten Strufe

Note: these slides have been prepared with influence by material of Prof. Jussi Kangasharju

Lecture Outline

- Who are we?
- Course outline
- Organizational matters

- The P2P scenario
- Reprise of DS models
- Reprise of DNS
- P2P in a nutshell
- What‘s also hard?
- History of P2P
- Current state
- The future of P2P

Course Outline and Goals

- Course topic is peer-to-peer systems
- Take a look at current state in P2P systems, both in “real world” and in research work

- What does P2P mean?
- Why does P2P work?
- What makes a good P2P system, how can their quality be evaluated?
- How is the P2P principle reflected in today’s systems?
- What are new challenges / applications for P2P?

Who we are…

- Fachgebiet „Peer-to-Peer Netzwerke“
  - Prof. Thorsten Strufe (Lectures)
    - Piloty A110 (*forget it, write me an email!* ☺)
    - strufe [at] cs.tu-darmstadt.de
  - Ikram Muhammad Khan
    - khan[at]cs.tu-darmstadt.de

  - Ana Barroso
  - Dominik Fischer

  - http://www.p2p.tu-darmstadt.de

Organizational matters

- Courses
  - Wed 9.50 – 11.30 (*semi c.t.*)
  - S2|02/C110
- Exercises
  - Tue 14.25 – 16.05
  - S2|02/C110
  - Both written and programming
  - Can be done in groups (of 2 ppl)
- Exams
  - Date: to be announced
  - Hopefully oral exams (if < 32 students)
  - Successfully completing exercises can buy you a bonus

- „The P2P-lecture“
    - http://www.p2p.tu-darmstadt.de/teaching/winter-term-20112012/p2p-networks-lecture/
  - Mailing list: p2p-ws11 [at] informatik.tu-darmstadt.de (please subscribe)
  - Forum „D120“ at „Fachschaft“

Material

- Slides will be available on the web site

  (please send emails to push me, there are millions of other things in my head! :-/)

- Literature
  - scholar.google.com/citeseer, „p2p“,“peer-to-peer“,…
  - google (avoid wikipedia, unless you only want a very first impression)
  - Books:
    - Coulouris, Dollimore, Kindberg: „Distributed Systems“
    - Raj Jain: „The art of computer systems performance evaluation“
    - Booth, Colomb, Williams: „The craft of research“
    - Steinmetz/Wehrle „P2P systems“ (free on the web, no close relation)

Questions?

Peer-to-Peer?

- What is it?

- What does the word “peer” mean?
  - Merriam-Webster: one that is of equal standing with another **:** EQUAL; *especially* **:** one belonging to the same societal group especially based on age, grade, or status

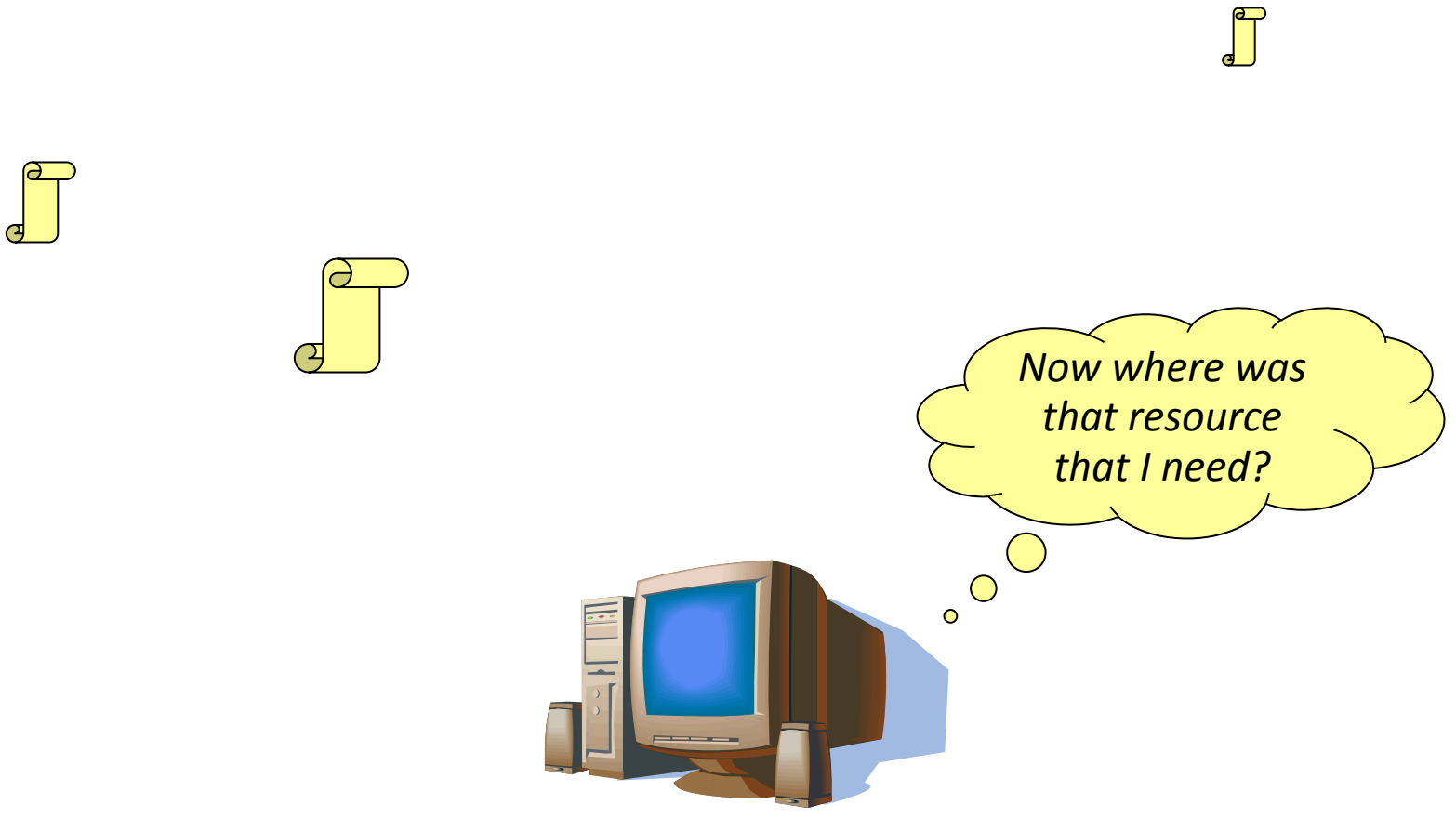
- Peer-to-peer: From one equal partner to another?

How do you define peer-to-peer?

What do you consider to be the main problems?

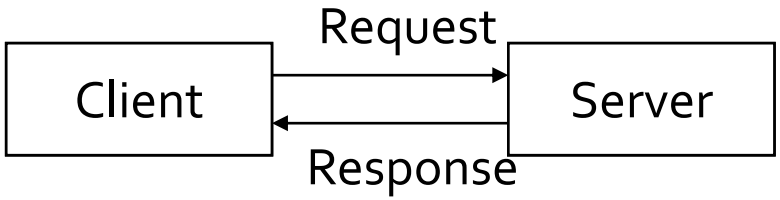
What do you think are the solutions (how does P2P work?)

The Peer-to-Peer Problem



Reprise: The client/server model

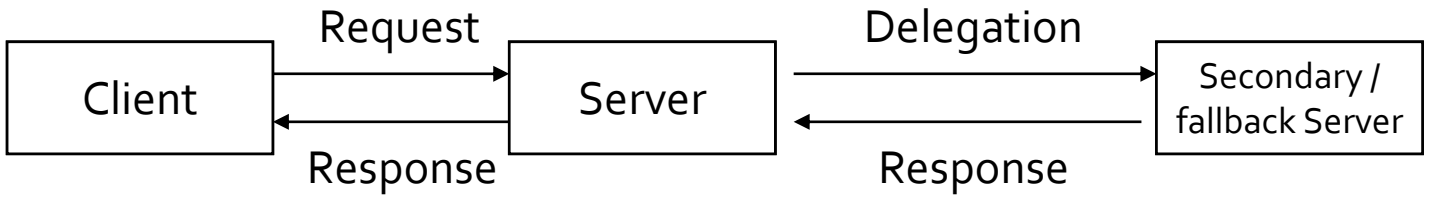
- Communication in request-response pairs
- The **role model** (the roles in the communication) is asymmetric
  - The client arrives and requests a service at any given point in time
  - The server is dedicated to the service and available and it responds immediately (well, after a processing time…)



- The **communication model** is asymmetric, too:
  - The clients send **requests** to a server
  - The server provides a solution and sends the results back in a **response**

Extended Client/Server Model

The client/server model is sometimes extended to more than two roles („client/server with delegation“)



- Definition of the clients remains the same:

  A **client** is, with respect to a considered service, the original and **initial source** of a **request** and the **sink for the response**.

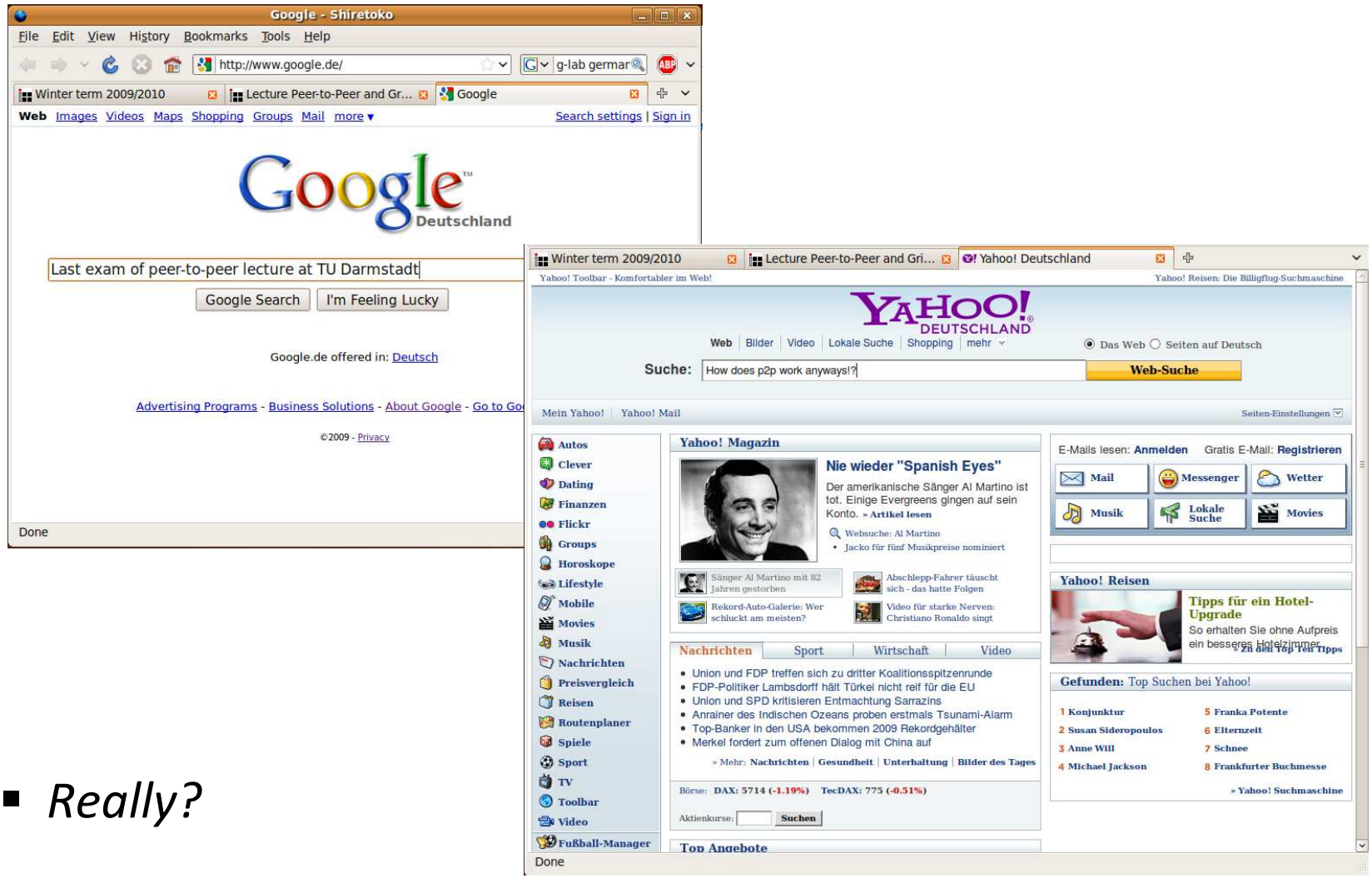
- Sidenote: Delegation may be *recursive* or *iterative*

- ***Beware!:*** *DNS calls or other services /external/ to the system are not part of the model!*

Locating Resources?

So how is it done in the Internet?

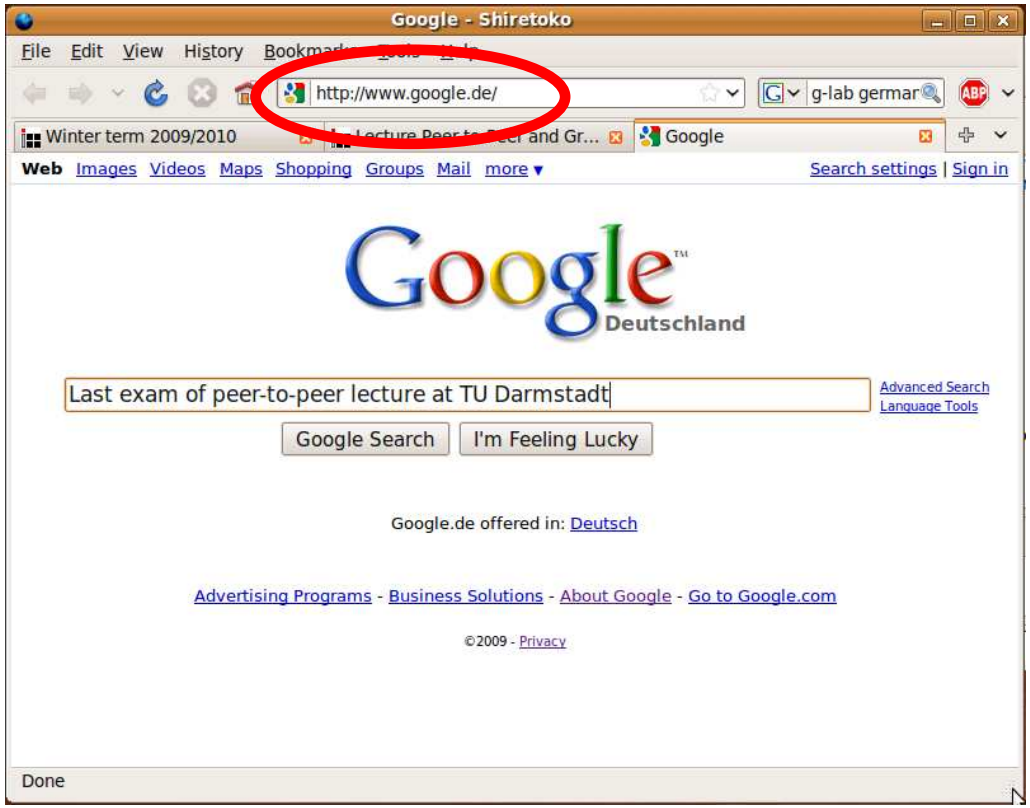
Real life resource location



- *Really?*

Reprise2: DNS – The Domain Name System

- Naming Service for (almost all) Internet traffic
- Lookup of (resolve)
  - Host-Addresses
  - Mail-Servers
  - Alias Names
  - Alternative Name Servers
  - …
- Distributed Database consisting of multitude of servers



DNS – Names

People: many identifiers:

- SSN, name, passport #

Internet hosts, routers:

- IP address (32 bit) - used for addressing datagrams
- "Name", e.g., www.yahoo.com - used by humans

Q: Map between IP addresses and name ?

Domain Name System:

Distributed database implemented in hierarchy of many *name servers*

Application-layer protocol: hosts, routers, name servers communicate to *resolve* names (address/name translation)

- Note: core Internet function, implemented as application-layer protocol
- Complexity at network's "edge"

DNS – what does it do?

DNS services

- Hostname to IP address translation
- Host aliasing
  - Canonical and alias names
- Mail server aliasing
- Load distribution
  - Replicated Web servers: set of IP addresses for one canonical name

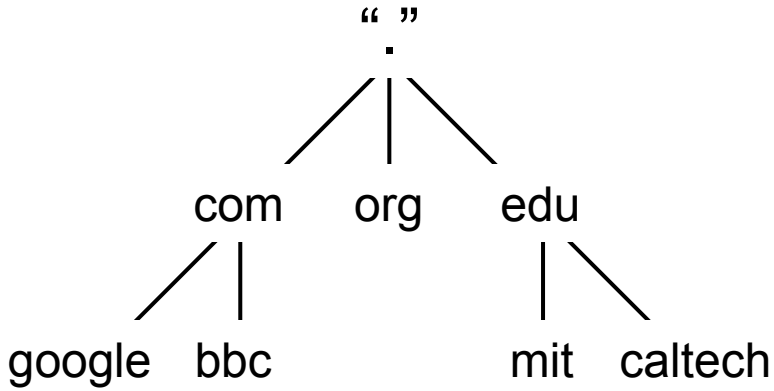
Why not centralize DNS?

- Single point of failure
- Traffic volume
- Distant centralized database
- Maintenance

does not *scale!*

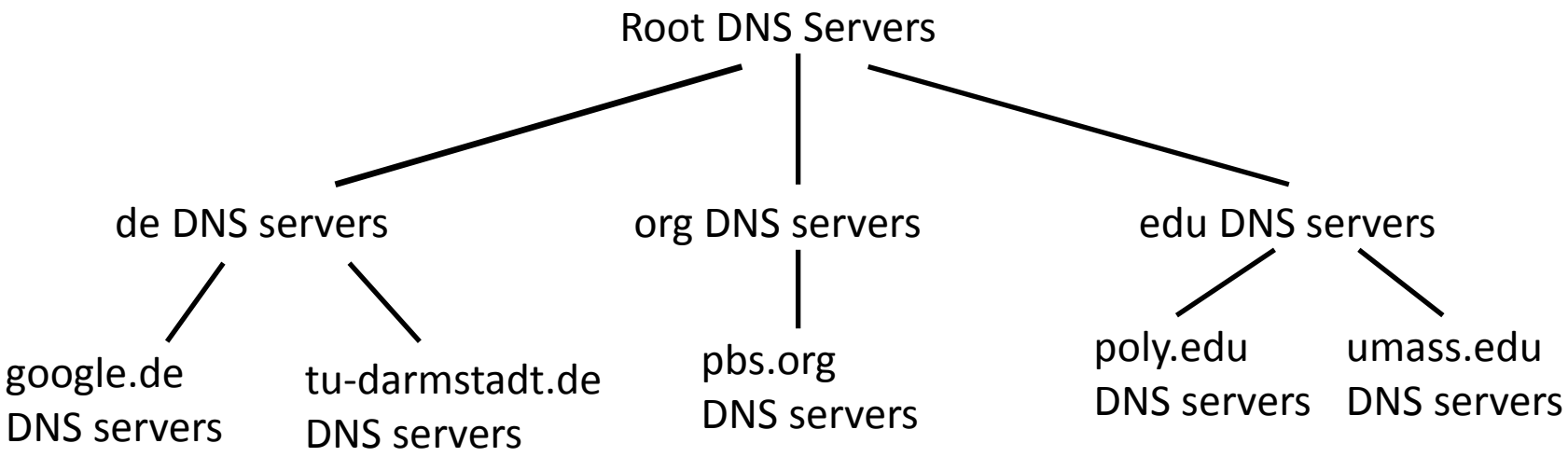
What does this „it scales“ mean anyways!?

DNS – Data Organization: Domains / Zones



- Structured Namespace
- Hierarchical organization in sub domains/zones
- Sourced at “root zone” (“.”)
- Parent zones maintain pointers to child zones (*“zone cuts”*)
- Zone data is stored as “Resource Records” (RR)

Distributed, Hierarchical Database



Client wants IP for www.p2p.tu-darmstadt.de; 1st approx:

- Client queries a root server to find **de** DNS server
- Client queries de DNS server to get **tu-darmstadt.de** DNS server
- Client queries tu-darmstadt.de DNS server to get IP address for www.p2p.tu-darmstadt.de

DNS: Root Name Servers

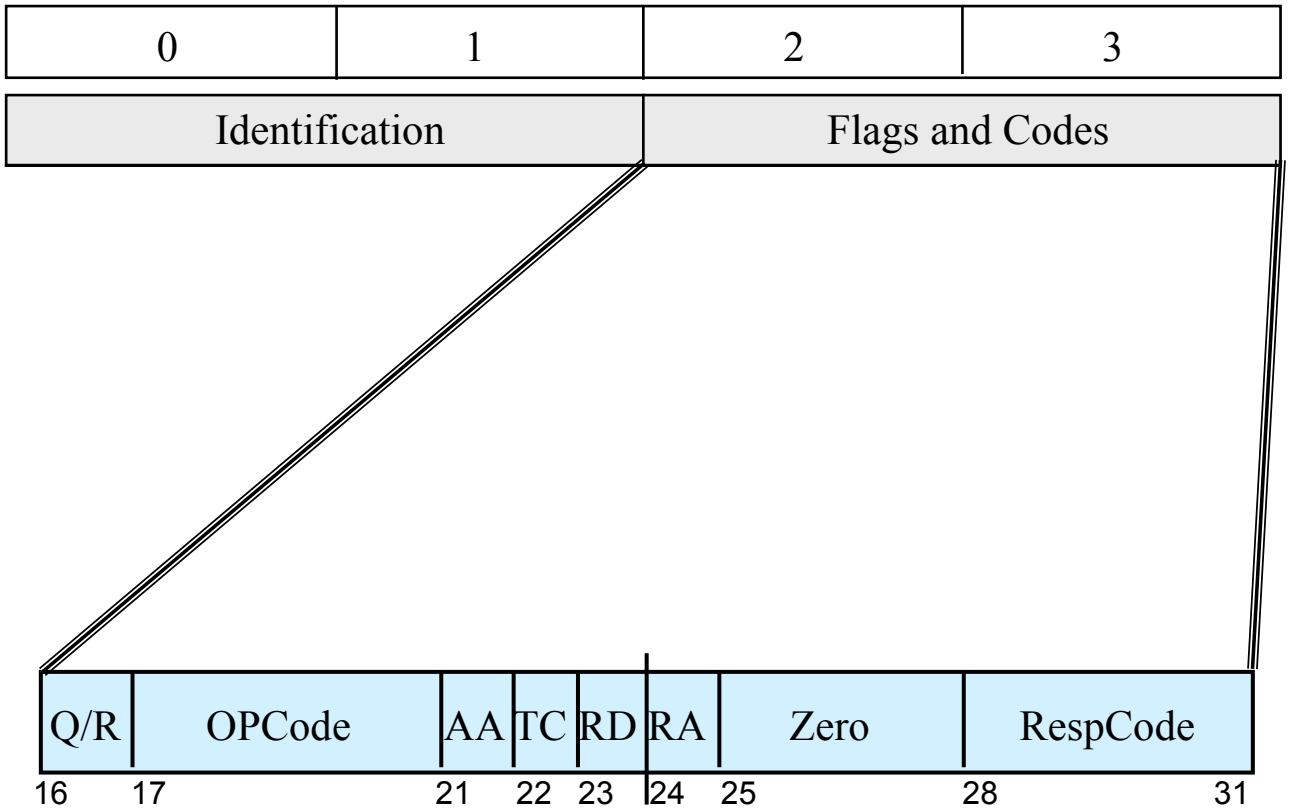
So, how many root nameservers are there actually? (physically)


http://www.circleid.com/posts/dns_root_servers_google_maps/
Greenland
Iceland
Canada
United States
México
North Atlantic Ocean
North Pacific Ocean
South Pacific Ocean
South Atlantic Ocean
Indian Ocean
Southern Ocean
Norge
Norway
Россия
Russia
Kazakhstan
Mongolia
China
S Korea
Japan
Italy
Spain
Iraq
Algeria
Libya
Egypt
Saudi Arabia
Mauritania
Mali
Niger
Chad
Sudan
Nigeria
Kenya
DR Congo
Tanzania
Angola
Namibia
Botswana
South Africa
Madagascar
Thailand
Indonesia
Papua New Guinea
Australia
New Zealand
Venezuela
Colombia
Perú
Bolivia
Brazil
Argentina

DNS – Components

- Authoritative Server
  - Server maintaining authoritative content of a complete DNS zone
  - Top-Level-Domain (TLD) servers & auth servers of organization's domains
  - Pointed to in parent zone as authoritative
  - Possible load balancing: master/slaves
- Recursive (Caching) Server
  - Local proxy for DNS requests
  - Caches content for specified period of time (soft-state with TTL)
  - If data not available in the cache, request is processed recursively
- Resolver
  - Software on client's machines (part of the OS)
  - Windows-* and *nix: Stub resolvers
    - Delegate request to local server
    - Recursive requests only, no support for iterative requests

DNS – Message Format



- Q/R *Query/Response Flag*
- *Operation Code*
- AA *Auth. Answer Flag*
- TC *Truncation Flag*
- RD *Recursion Desired Flag*
- RA *Recursion Available Flag*
- Zero (three resv. bits)
- *Response Code*

DNS – Header Fields

- *Identifier:* a 16-bit identification field generated by the device that creates the DNS query. It is copied by the server into the response, so it can be used by that device to match that query to the corresponding reply
- *Query/Response Flag:* differentiates between queries and responses (0 ~ Query, 1 ~ Response)
- *Operation Code:* specifies the type of message (Query, Status, Notify, Update)
- *Authoritative Answer Flag (AA):* set to1 if the answer is authoritative
- *Truncation Flag:* When set to 1, indicates that the message was truncated due to its length (might happen with UDP, requestor can then decide to ask again with TCP as transport service)
- *Recursion Desired:* set to 1 if requester desired recursive processing
- *Recursion Available:* set to 1 if server supports recursive queries

TLD, Authoritative and Local DNS Servers

- Top-level domain (TLD) servers:
  - responsible for com, org, net, edu, etc, and all top-level country domains uk, fr, ca, jp
  - Network solutions maintains servers for **com** TLD
  - Educause for **edu** TLD
- Authoritative DNS servers:
  - organization's DNS servers, providing authoritative hostname to IP mappings for organization's servers (e.g., Web and mail).
  - Can be maintained by organization or service provider
- Local DNS servers:
  - Does not strictly belong to hierarchy
  - Each ISP (residential ISP, company, university) has one
    - Also called "default name server"
  - When a host makes a DNS query, query is sent to its local DNS server
    - Acts as a proxy, forwards query into hierarchy

DNS – Resource Records

- Atomic entries in DNS are called “Resource Records” (RR)
- Format:

  <name> [<ttl>] [<class>] <type> <rdata>

  - `name` (domain name of resource)
  - `ttl` (Time-to-live)
  - `class` (used protocol): IN (Internet), CH (Chaosnet)…
  - `type` (record type): A (Host-Address), NS (Name Server), MX (Mail Exchange), CNAME (Canonical Name), AAAA (IPv6-Host-Address), DNAME (CNAME, IPv6)
  - `rdata` (resource data): Content! (What did we want to look up?)

DNS Records

DNS: Distributed DB storing resource records (RR)

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

- Type=A
  - **`name`** is hostname
  - **`value`** is IP address
- Type=NS
  - **`name`** is domain (e.g. foo.com)
  - **`value`** is IP address of authoritative name server for this domain
- Type=MX
  - **`value`** is name of mailserver associated with **`name`**
- 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