CS118 Discussion 1C, Week 2

Zhehui Zhang

Outline

- Quiz – logistics
- Socket programming review
- Lecture Review
- Packet delay, loss, throughput
- Applications
  - HTTP (persistent/parallel), SMTP, DNS, etc

Quiz 1 - logistics

Suggestions from Prof. Lu

1. Quiz 1 will cover Chapters 1 and 2. The materials to study are the lecture notes, homeworks, programming project 1 (see the sample quiz regarding how socket programming from Project 1 can be tested), and textbooks.

2. You do not need to memorize a lot of acronyms as shown in the textbook or slides. Wherever needed, we will give the full name (such as SMTP (simple mail transfer protocol).

3. Do show your steps in your answer to receive partial credit, so that we know how you think to maximize your received credit.

Quiz 1 - logistics

- Time: 6-8pm (PST), Thursday, Apr 23
  - Email me if you cannot make it
- Format: sample quiz posted on line

1. Which of the following statement is true?

   - Your answer ____ (A) HTTP is a transport-layer protocol. (B) Modularity through protocol layering makes it easier to update system components. (C) POP3 is not an application-layer protocol. (D) SMTP uses UDP protocol at its transport layer. (E) DNS is not needed for the Internet.
   - Justification:

Socket programming review

4. Briefly explain the main steps for socket programming with TCP on the client side. You do not need to list the detailed function calls.

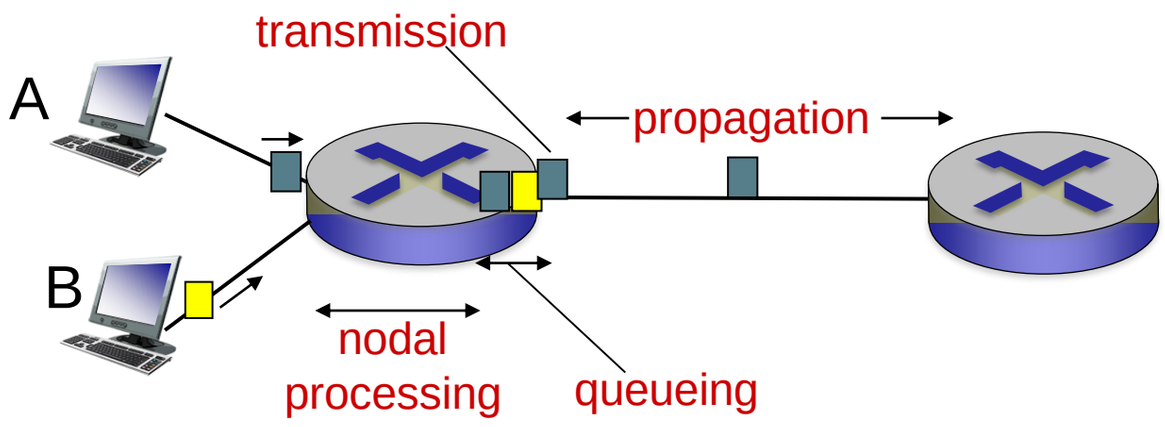
Joe is writing programs with a client and a server that use stream sockets. The following is the SERVER code that Joe wrote. Can you help Joe to find at least four errors in his code ? You can mark your answers in his code, and label the errors in the code. You can use the Appendix for references.

```
#include <server.h>
#define MYPORT 3490    /* the port users will be connecting to */
#define BACKLOG 10     /* how many pending connections queue will hold */
main()
{
    int sockfd, new_fd;  /* listen on sock_fd, new connection on new_fd */
    struct sockaddr_in my_addr;    /* my address information */
    struct sockaddr_in their_addr; /* connector's address information */
    int sin_size;

    if ((sockfd = socket(AF_INET, SOCK_DGRAM, 0)) == -1) {
        perror("socket");
        exit(1); }

    my_addr.sin_family = AF_INET;         /* host byte order */
    my_addr.sin_port = htons(MYPORT);     /* short, network byte order */
    my_addr.sin_addr.s_addr = INADDR_ANY; /* auto-fill with my IP */
```

Socket programming review

```
bzero(&(my_addr.sin_zero), 8);        /* zero the rest of the struct */

if (bind(sockfd, (struct sockaddr *)&my_addr, sizeof(struct sockaddr))== -1) {
    perror("bind");
    exit(1);  }

if (accept(sockfd, BACKLOG) == -1) {
    perror("accept");
    exit(1); }

while(1) {  /* main loop */
    sin_size = sizeof(struct sockaddr_in);
    if ((new_fd = listen(sockfd, (struct sockaddr *)&their_addr, &sin_size)) == -1){
        perror("listen");
        continue;  }
    printf("server: got connection from %s\n", inet_ntoa(their_addr.sin_addr));
    if (fork()) { /* this is the child process */
        if (sendto(new_fd, "Hello, world!\n", 14, 0) == -1)
            perror("sendto");
        close(new_fd);
        exit(0); }

    close(new_fd);  /* parent doesn't need this */
   while(waitpid(-1,NULL,WNOHANG) > 0); /* clean up child processes */ }}
```

Packet delay review



$$d_{nodal} = d_{proc} + d_{queue} + d_{trans} + d_{prop}$$

d_{proc}: nodal processing
- check bit errors
- determine output link

d_{queue}: queueing delay [DEMO]
- time waiting at output link for transmission
- depends on congestion level of router

d_{trans}: transmission delay:
- *L*: packet length (bits)
- *R*: link *bandwidth (bps)*
- $d_{trans} = L/R$

d_{prop}: propagation delay:
- *d*: length of physical link
- *s*: propagation speed (~2×10^8 m/sec)
- $d_{prop} = d/s$

Question

a. How long does it take a packet of length 1000 bytes to propagate over a link of distance 2500km, propagation speed 2.5x10^8 m/s, and transmission rate 2 Mbps?

b. More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps?

c. Dose this delay depend on packet length?

d. Does this delay depend on transmission rate?

Solution

a. How long does it take a packet of length 1000 bytes to propagate over a link of distance 2500km, propagation speed 2.5x10^8 m/s, and transmission rate 2 Mbps?

- Ans: (2500*10^3)/(2.5*10^8)=0.01s = 10ms

b. More generally, how long does it take a packet of length L to propagate over a link of distance d, propagation speed s, and transmission rate R bps? **Ans: d/s**

c. Dose this delay depend on packet length? Ans: No

d. Does this delay depend on transmission rate? Ans: No

Question

- Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R_1=500kbps, R_2=2Mbps, and R_3=1Mbps.

  a. Assuming no other traffic in the network, what is the throughput for the file transfer?

  b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?

  c. Repeat (a) and (b), but now with R_2 reduce to 100kpbs.

Solution

a. Assuming no other traffic in the network, what is the throughput for the file transfer? **Ans: 500 kbps**

b. Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B? **Ans: (4*10^6)*8/(500*10^3)= 64 seconds**

c. Repeat (a) and (b), but now with R2 reduce to 100kpbs. **Ans: 320 seconds**

Question cont'd

- Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates R_1=500kbps, R_2=100kbps, and R_3=1Mbps.

  d. Suppose the file is 200 bytes and it is segmented into two 100 bytes packets. What is the queuing delay for the second packet at host A, the first node, the second node?

Question

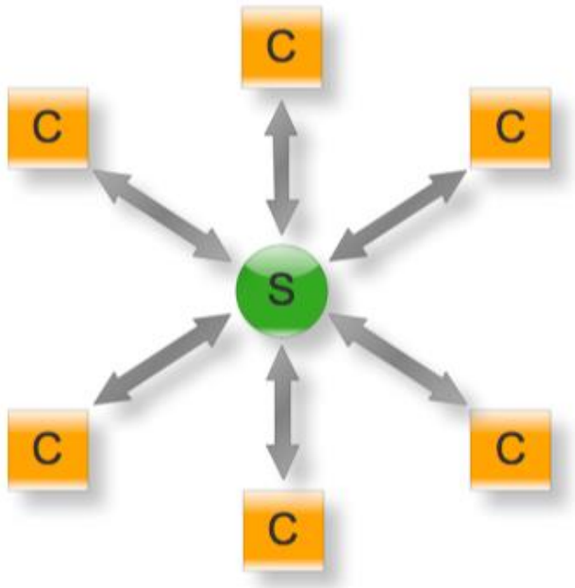
- Consider an HTTP client that wants to retrieve a Web document at a given URL. The IP address of the HTTP server is initially unknown. What transport and application layer protocols besides HTTP are needed in this scenario?

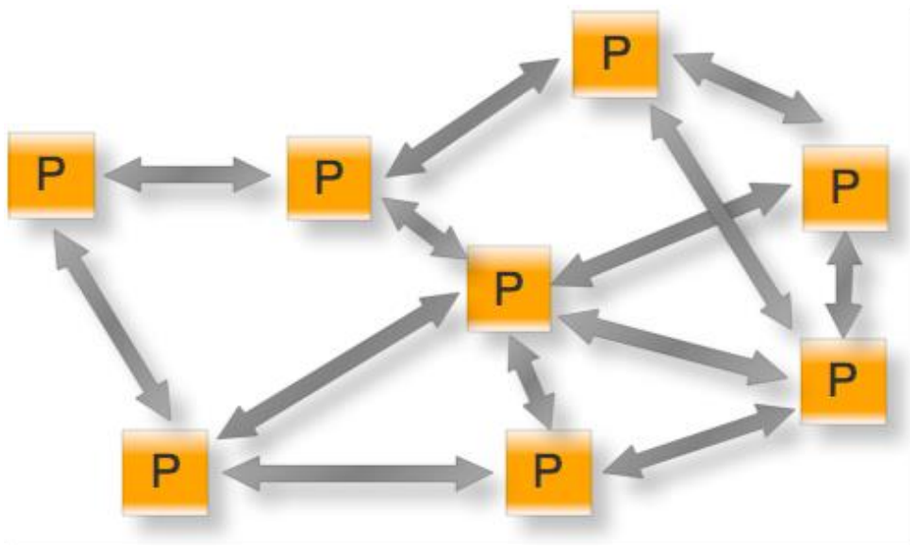
Solution

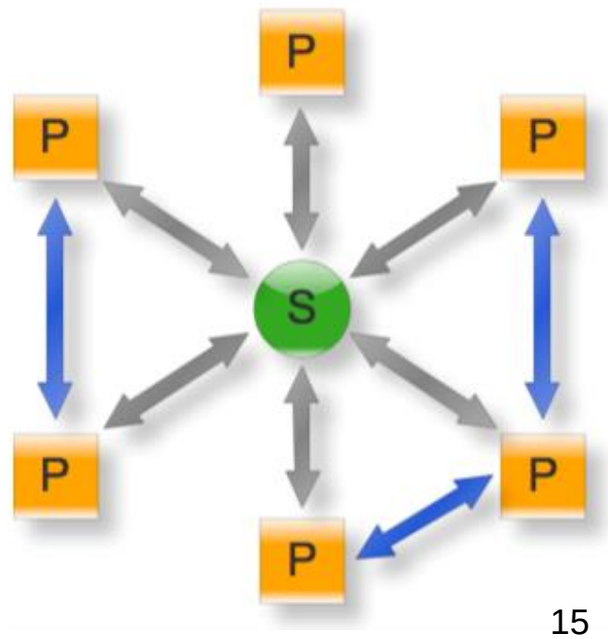
- Application layer protocols: DNS and HTTP
- Transport layer protocols: UDP for DNS; TCP for HTTP

Application Layer: Models

- Application Architectures
  - Client-server model: Web (TCP), FTP (TCP), E-mail (TCP), DNS (UDP/TCP), RTP
  - Peer-to-Peer (P2P): BitTorrent (TCP), Tor (aka Onion Routing, TCP)
- Hybrid model: Skype (TCP&UDP), GTalk (TCP&UDP)



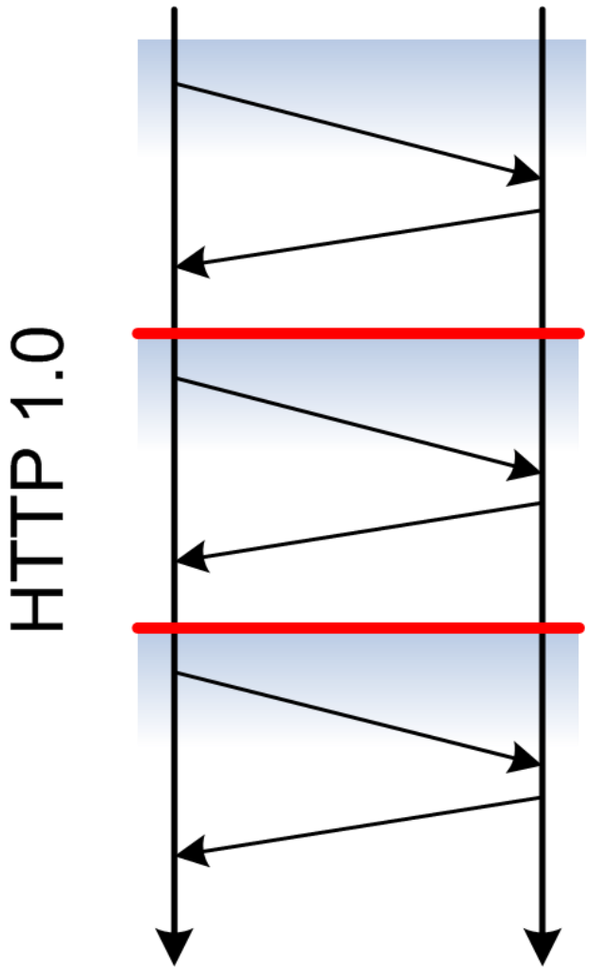


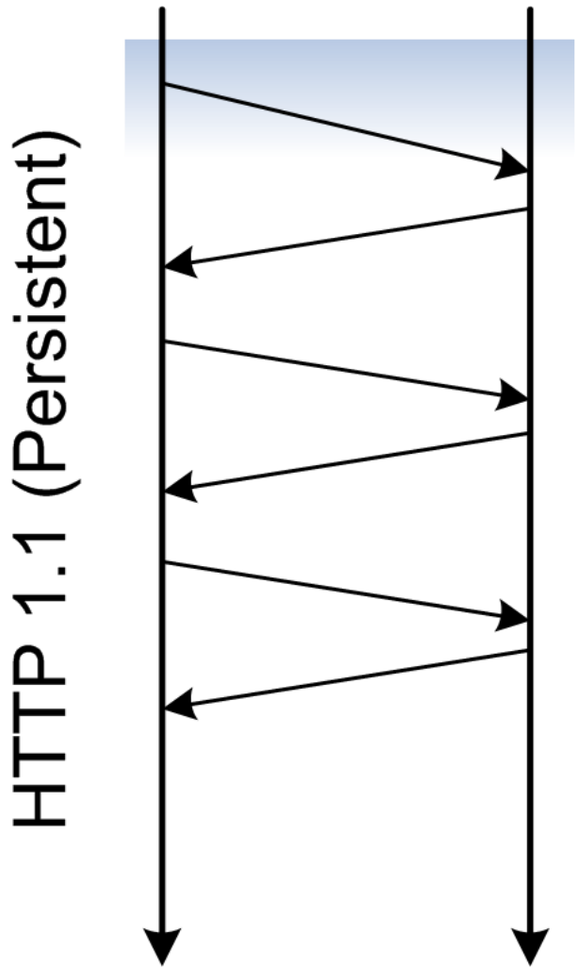


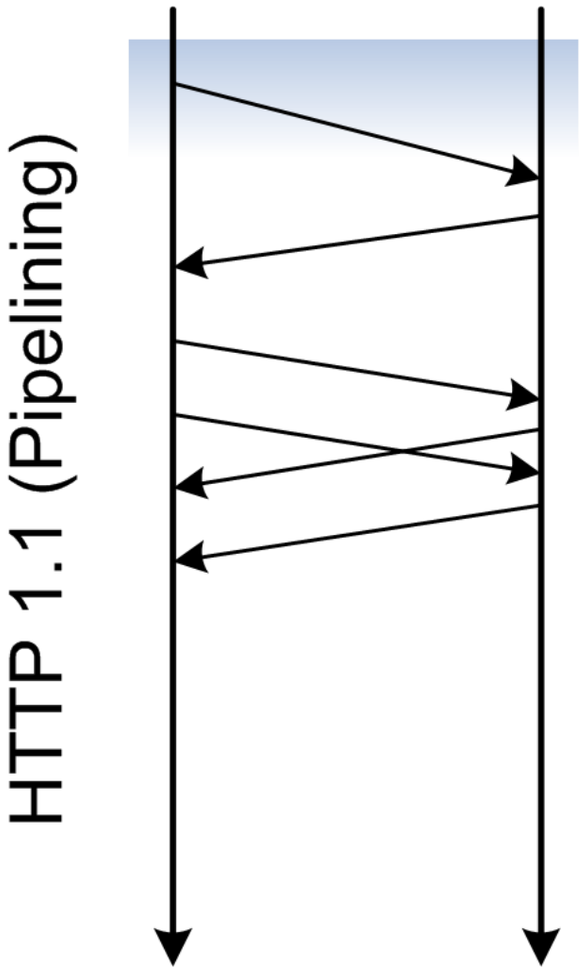
Application Layer: Protocols

- HTTP: a stateless protocol on top of TCP
  - HTTP is based on pull model
  - Persistent HTTP V.S. Non-persistent HTTP
  - Method Types: GET, HEAD, POST, PUT, DELETE, Conditional GET
  - What if we want stateful service (e.g. shopping cart)?
  - Web Caches (proxy server)

Non-persistent v.s. Persistent v.s. Pipelining







Question

- How many TCP connections do we need to get one HTML file with 5 embedded images? How many RTTs shall we need?

- Demo (note: calculate of transmission delay in this demo when there are parallel TCP connection is wrong!)

- Transmission delay of one object in one TCP connection is 0.25 RTT -> transmission delay of two objects in two TCP connection would be 0.5 RTT (Link rata for one connection reduce by half since two connections are sharing the link!)

HTTP Header: request

- Request message elements:
  - Method
  - URL
  - HTTP Version
  - Header lines
  - CRLF (carriage return and line feed)

HTTP Header: response

- Response message elements:
  - HTTP Version
  - Status line
  - Header lines
  - CRLF
  - Data requested

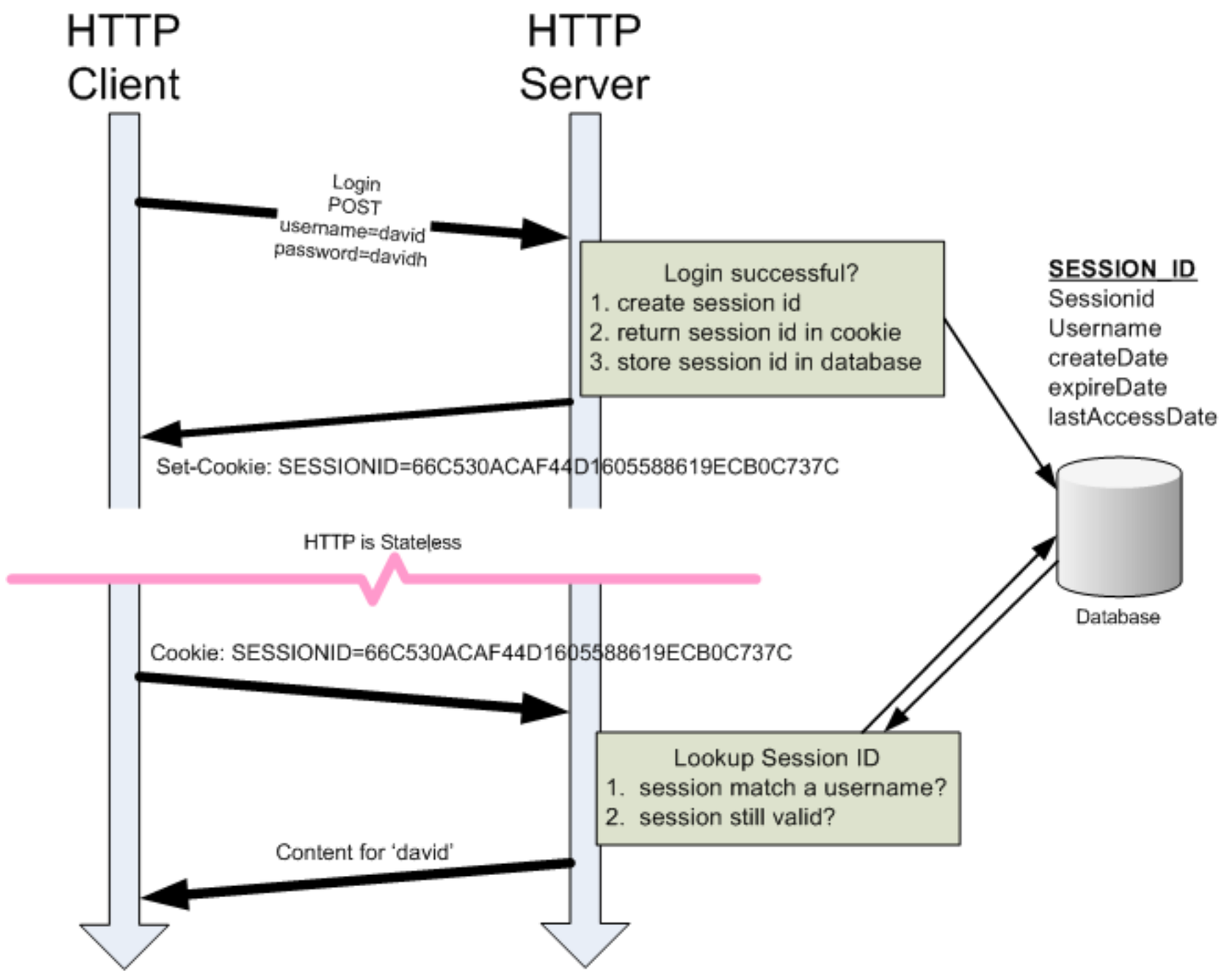
Try HTTP GET yourself

- telnet google.com 80
  - Get / HTTP/1.1
  - Host: google.com
  - <Enter>
  - <Enter>

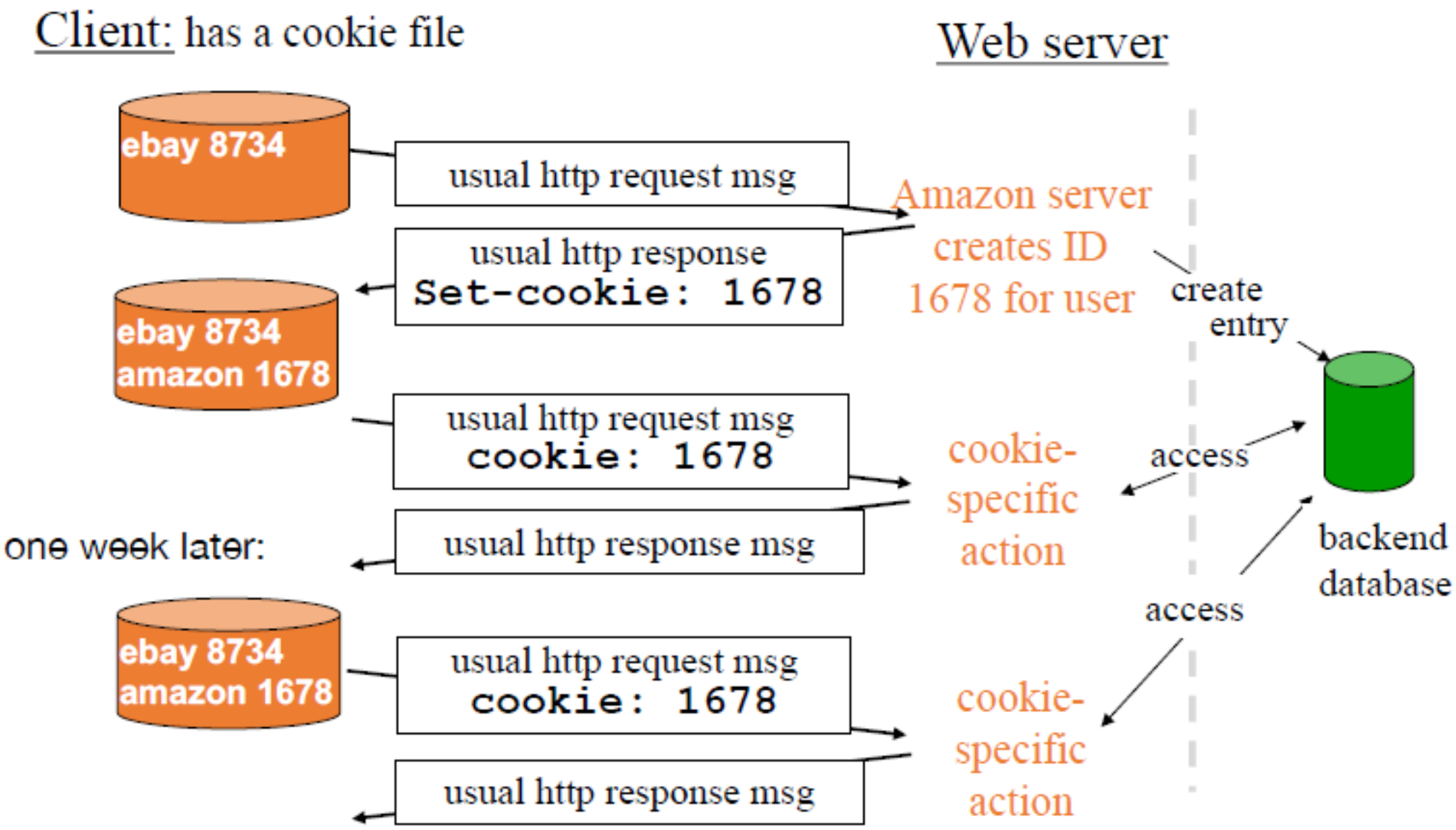
Cookie

- Bring statefulness into HTTP
- Components
  - Cookie header line of HTTP response message
  - Cookie header line of HTTP request message
  - Cookie file on the browser
  - Back-end database at web-site

Cookie: make HTTP stateful



Cookie: operations



Web caching: Proxy v.s. CDN

- Proxy acts both as client and server
  - What if cache is stale?
    - HTTP conditional GET
- CDN: Content Distribution Network
  - Globally distributed network of web servers
  - Stores and replicates images, videos and other files

HTTP conditional GET

Request:

GET /sample.html HTTP/1.1

Host: example.com

Response:

HTTP/1.x 200 OK

Via: The-proxy-name

Content-Length: 32859

Expires: Tue, 27 Dec 2005 11:25:11 GMT

Date: Tue, 27 Dec 2005 05:25:11 GMT

Content-Type: text/html; charset=iso-8859-1

Server: Apache/1.3.33 (Unix) PHP/4.3.10

Cache-Control: max-age=21600

Last-Modified: Wed, 01 Sep 2004 13:24:52 GMT

Etag: “4135cda4”

Cache-Control: It tells the client the maximum time in seconds to cache the document.

Last-Modified: The document’s last modified date

Etag: A unique hash for the document.

HTTP conditional GET

Request:

GET /sample.html HTTP/1.1

Host: example.com

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Cache-Control: max-age=21600

Last-Modified: Wed, 01 Sep 2004 13:24:52 GMT

Etag: “4135cda4”

Request:

GET /sample.html HTTP/1.1

Host: example.com

If-Modified-Since: Wed, 01 Sep 2004 13:24:52 GMT

If-None-Match: “4135cda4”

Response:

HTTP/1.x 304 Not Modified

Via: The-proxy-server

Expires: Tue, 27 Dec 2005 11:25:19 GMT

Date: Tue, 27 Dec 2005 05:25:19 GMT

Server: Apache/1.3.33 (Unix) PHP/4.3.10

Keep-Alive: timeout=2, max=99

Etag: “4135cda4”

Cache-Control: max-age=21600

Question

Consider the following string of ASCII characters that were captured by Wireshark when the browser sent an HTTP GET message.

a. What is the URL of the document requested by the browser?

b. What version of HTTP is the browser running?

c. Does the browser request a non-persistent or a persistent connection?

```
GET /118/index.html HTTP/1.1<cr><lf>Host: gai
a.cs.umass.edu<cr><lf>User-Agent: Mozilla/5.0 (
Windows;U;Windows NT 5.1; en-US; rv:1.7.2) Gec
ko/20040804 Netscape/7.2 (ax) <cr><lf>Accept:ex
t/xml, application/xml, application/xhtml+xml, text
/html;q=0.9, text/plain;q=0.8,image/png,*/*;q=0.5
<cr><lf>Accept-Language: en-us,en;q=0.5<cr><lf>
AcceptEncoding: zip,deflate<cr><lf>Accept-Charset: ISO
-8859-1,utf-8;q=0.7,*;q=0.7<cr><lf>Keep-Alive: 300<cr>
<lf>Connection:keep-alive<cr><lf><cr><lf>
```

Question

Consider the following string of ASCII characters that were captured by Wireshark when the browser sent an HTTP GET message.

d. What is the IP address of the host on which the browser is running?

e. What type of browser initiates this message? Why is the browser type needed in an HTTP request message?

GET /118/index.html HTTP/1.1<cr><lf>Host: gai
a.cs.umass.edu<cr><lf>User-Agent: Mozilla/5.0 (
Windows;U;Windows NT 5.1; en-US; rv:1.7.2) Gec
ko/20040804 Netscape/7.2 (ax) <cr><lf>Accept:ex
t/xml, application/xml, application/xhtml+xml, text
/html;q=0.9, text/plain;q=0.8,image/png,*/*;q=0.5
<cr><lf>Accept-Language: en-us,en;q=0.5<cr><lf>
AcceptEncoding: zip,deflate<cr><lf>Accept-Charset: ISO
-8859-1,utf-8;q=0.7,*;q=0.7<cr><lf>Keep-Alive: 300<cr>
<lf>Connection:keep-alive<cr><lf><cr><lf>

Question

The text below shows the reply sent from the server in response to the HTTP GET message in the question above.

a. As the server able to successfully find the document or not? What time was the document reply provided?

b. When was the document last modified?

c. How many bytes are there in the document being returned?

d. What are the first 5 bytes of the document being returned? Did the server agree to a persistent connection?

HTTP/1.1 200 OK<cr><lf>Date: Tue, 07 Mar 2008 12:39:45GMT<cr><lf>Server: Apache/2.0.52 (Fedora) <cr><lf>Last-Modified: Sat, 10 Dec2005 18:27:46 GMT<cr><lf>ETag: "526c3-f22-a88a4c80"<cr><lf>Accept- Ranges: bytes<cr><lf>Content-Length: 3874<cr><lf> Keep-Alive: timeout=max=100<cr><lf>Connection: Keep-Alive<cr><lf>Content-Type: text/html; charset =ISO-8859-1<cr><lf><cr><lf><!doctype html public "-//w3c//dtd html 4.0 transitional//en"><lf><html><lf> <head><lf> <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1"><lf><meta name="GENERATOR" content="Mozilla/4.79 [en] (Windows NT 5.0; U) Netscape]"><lf> <title>CMPSCI 453 / 591 / NTU-ST550A Spring 2005 homepage</title><lf></head><lf> <much more document text following here (not shown)>

Application Layer: Protocols

- FTP: separate control from data transmission (“out-of-band”)
- SMTP: protocol for email exchange between email servers
  - SMTP is based on push model
  - Mail access protocol: POP, IMAP, HTTP-based
- P2P: no always-on server, peers are intermittently connected
  - BitTorrent: tracker and torrent. Files are divided into multiple chunks.

Application Layer: Protocols

- DNS: convert hostname to IP address (and more)
- A distributed and hierarchical database
    - Root DNS servers
    - Top-level domain (TLD) servers
    - Authoritative DNS servers
    - local DNS server (aka, DNS resolver)

Application Layer: protocols

- DNS:
  - What is the transport layer protocol?
  - How the scalability is achieved?
  - Who will use iterative/recursive query?
  - Why is DNS resolver needed?

Application Layer: protocols

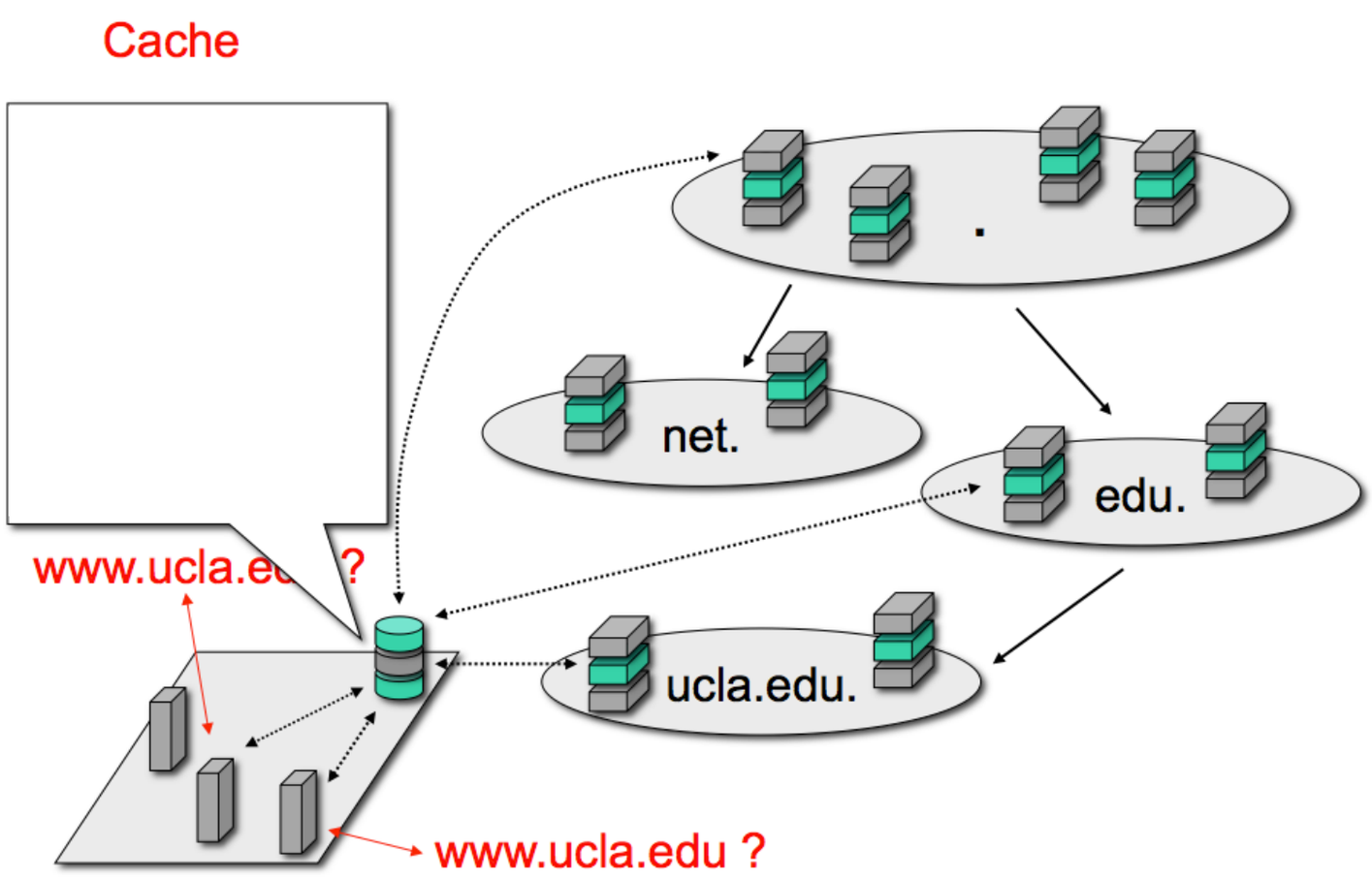
- DNS:
  - What is the transport layer protocol? UDP
  - How the scalability is achieved? Distributed records
  - Who will use iterative/recursive query? DNS resolver
  - Why is DNS resolver needed? Reduce latency

DNS protocol: exercise

- Assume the cache is empty initially
- Host A queries www.ucla.edu, how many queries should the resolver issue?
- After A's DNS query, host B queries www.mit.edu, how many queries should the resolver issue?

DNS protocol: exercise

- Assume the cache is empty initially
- Host A queries www.ucla.edu, how many queries should the resolver issue?



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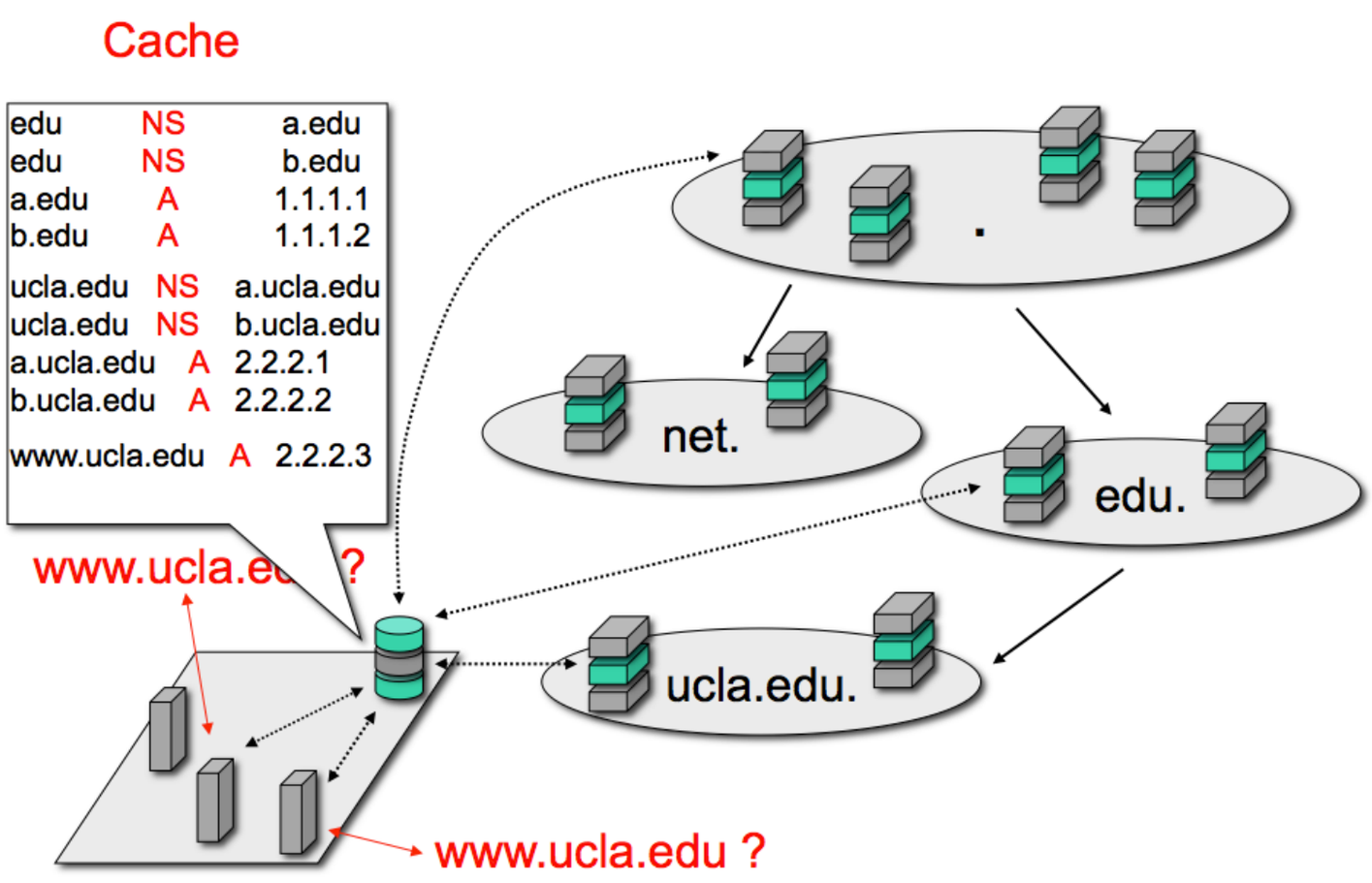

DNS protocol: exercise

- Assume the cache is empty initially
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A fun experiment: DNS query

```
$ dig google.com
; <<>> DiG 9.8.3-P1 <<>> google.com
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 44777
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 4, ADDITIONAL: 4

;; QUESTION SECTION:
;google.com.          IN  A

;; ANSWER SECTION:
google.com.    76  IN  A   172.217.2.14

;; AUTHORITY SECTION:
google.com.    85950   IN  NS  ns3.google.com.
google.com.    85950   IN  NS  ns4.google.com.
google.com.    85950   IN  NS  ns1.google.com.
google.com.    85950   IN  NS  ns2.google.com.

;; ADDITIONAL SECTION:
ns1.google.com.    59591   IN  A   216.239.32.10
ns2.google.com.    50756   IN  A   216.239.34.10
ns3.google.com.    40354   IN  A   216.239.36.10
ns4.google.com.    36005   IN  A   216.239.38.10

;; Query time: 84 msec
;; SERVER: 158.69.209.100#53(158.69.209.100)
;; WHEN: Thu Jan 19 20:37:48 2017
;; MSG SIZE  rcvd: 180
$ dig any mit.edu
```

DNS parameters note