Computer Network & Management

Application Layer

Soo-Hyun Choi
soohyunc@msn.com

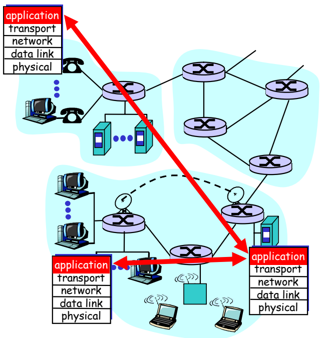
Sept. 13, 2005

Contents

Applications and application-layer protocols

Application: communicating, distributed processes
- running in network hosts in "user space"
- exchange messages to implement application
- e.g., email, ftp, Web

Application-layer protocols
- one "piece" of an app
- define messages exchanged by apps and actions taken
- use communication services provided by lower layer protocols (TCP, UDP)
- SMTP, FTP, HTTP

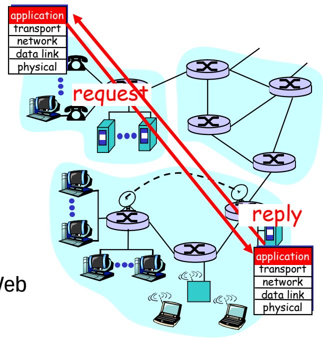


* How to identify process? IP address and Port number

Client-server paradigm

Client:
- initiates contact with server ("speaks first")
- typically requests service from server
- Web: client implemented in browser

Server:
- provides requested service to client
- e.g., Web server sends requested Web page



Peer-to-Peer ?

Application-layer protocols

HTTP, SMTP, FTP, Telnet, Proprietary Protocols, …

Application-layer protocols are implemented using Socket API which is provided by Operating System.

API: application programming interface
- defines interface between application and transport layers
- socket: Internet API
  - two processes communicate by sending data into socket, reading data out of socket

application
transport
network
link
physical

What transport service does an app need?

Data loss
- some apps (e.g., audio) can tolerate some loss
- other apps (e.g., file transfer, telnet) require 100% reliable data transfer

Timing
- some apps (e.g., Internet telephony, interactive games) require low delay to be "effective"

Bandwidth
- some apps (e.g., multimedia) require minimum amount of bandwidth to be "effective"
- other apps ("elastic apps") make use of whatever bandwidth they get

Transport service requirements of common apps

Application	Data loss	Bandwidth	Time Sensitive
file transfer	no loss	elastic	no
e-mail	no loss	elastic	no
Web documents	loss-tolerant	elastic	no
real-time audio/video	loss-tolerant	audio: 5Kb-1Mb video:10Kb-5Mb	yes, 100's msec
stored audio/video	loss-tolerant	same as above	yes, few secs
interactive games	loss-tolerant	few Kbps up	yes, 100's msec
financial apps	no loss	elastic	yes and no

Internet transport protocols services

TCP service:
- *connection-oriented:* setup required between client, server
- *reliable transport* between sending and receiving process
- *flow control:* sender won't overwhelm receiver
- *congestion control:* throttle sender when network overloaded
- *does not providing:* timing, minimum bandwidth guarantees

UDP service:
- unreliable data transfer between sending and receiving process
- does not provide: connection setup, reliability, flow control, congestion control, timing, or bandwidth guarantee

Q: Why is there a UDP? , Why only two protocols?

Internet apps: application, transport protocols

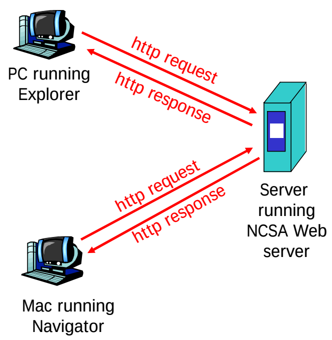
Application	Application layer protocol	Underlying transport protocol
e-mail	smtp [RFC 821]	TCP
remote terminal access	telnet [RFC 854]	TCP
Web	http [RFC 2068]	TCP
file transfer	ftp [RFC 959]	TCP
streaming multimedia	proprietary (e.g. RealNetworks)	TCP or UDP
remote file server	NSF	TCP or UDP
Internet telephony	proprietary (e.g., Vocaltec)	typically UDP

Web and HTTP

The Web: the HTTP protocol

HTTP: hypertext transfer protocol

- Web's application layer protocol
- client/server model
  - *client:* browser that requests, receives, "displays" Web objects
  - *server:* Web server sends objects in response to requests
- http1.0: RFC 1945
- http1.1: RFC 2068



The http protocol: more

http: TCP transport service:

- client initiates TCP connection (creates socket) to server, port 80
- server accepts TCP connection from client
- http messages (application-layer protocol messages) exchanged between browser (http client) and Web server (http server)
- TCP connection closed

http is "stateless"

- server maintains no information about past client requests

aside

Protocols that maintain "state" are complex!

- past history (state) must be maintained
- if server/client crashes, their views of "state" may be inconsistent, must be reconciled

http example

Suppose user enters URL
www.ucl.ac.uk/ (contains text, references to some jpeg images)

1a. http client initiates TCP connection to http server (process) at www.ucl.ac.uk. Port 80 is default for http server.

1b. http server at host www.ucl.ac.uk waiting for TCP connection at port 80. "accepts" connection, notifying client

2. http client sends http *request message* (containing URL) into TCP connection socket

3. http server receives request message, forms *response message* containing requested object (/index.html), sends message into socket

time

http example (cont.)

4. http server closes TCP connection.

5. http client receives response message containing html file, displays html. Parsing html file, finds 10 referenced jpeg objects

6. Steps 1-5 repeated for each of 10 jpeg objects

time

Non-persistent, persistent connections

Non-persistent

- http/1.0: server parses request, responds, closes TCP connection
- (2 + x) RTTs to fetch object
  - TCP connection
  - object request/transfer
- each transfer suffers from TCP's initially slow sending rate
- many browsers open multiple parallel connections

Persistent

- default for http/1.1
- on same TCP connection: server, parses request, responds, parses new request,..
- client sends requests for all referenced objects as soon as it receives base HTML.
- fewer RTTs, less slow start.
- With pipelining and without pipelining.

http message format: request

- two types of http messages: *request*, *response*
- http request message:
  - ASCII (human-readable format)

request line (GET, POST, HEAD commands)

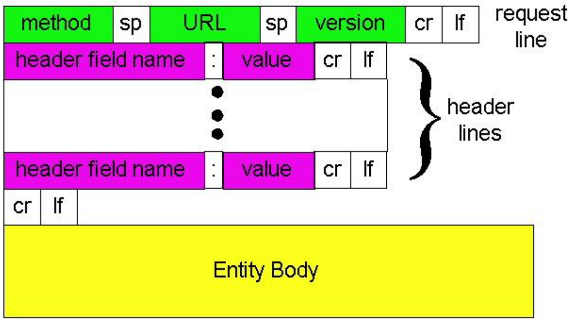
```
GET /somedir/page.html HTTP/1.0
User-agent: Mozilla/4.0
Accept: text/html, image/gif,image/jpeg
Accept-language:fr
```

header lines

(extra carriage return, line feed)

Carriage return, line feed indicates end of message

http request message: general format



http message format: response

status line (protocol status code status phrase)

```
HTTP/1.0 200 OK
Date: Thu, 06 Aug 1998 12:00:15 GMT
Server: Apache/1.3.0 (Unix)
Last-Modified: Mon, 22 Jun 1998 …...
Content-Length: 6821
Content-Type: text/html

data data data data data ...
```

header lines

data, e.g., requested html file

http response status codes

In first line in server->client response message.

A few sample codes:

200 OK
- request succeeded, requested object later in this message

301 Moved Permanently
- requested object moved, new location specified later in this message (Location:)

400 Bad Request
- request message not understood by server

404 Not Found
- requested document not found on this server

505 HTTP Version Not Supported

Trying out http (client side) for yourself

1. Telnet to your favorite Web server:

`telnet www.eurecom.fr 80`

Opens TCP connection to port 80 (default http server port) at www.eurecom.fr. Anything typed in sent to port 80 at www.eurecom.fr

2. Type in a GET http request:

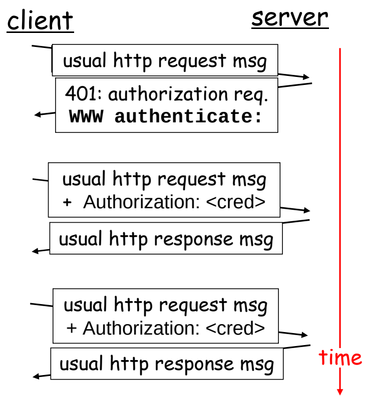
`GET /~ross/index.html HTTP/1.0`

By typing this in (hit carriage return twice), you send this minimal (but complete) GET request to http server

3. Look at response message sent by http server!

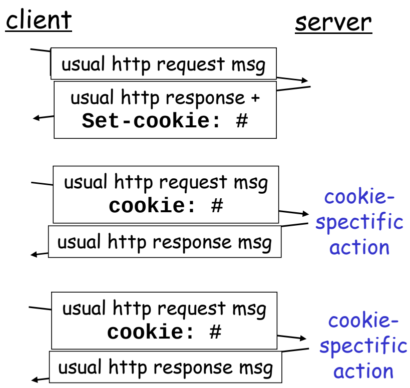
User-server interaction: authentication

Authentication : control access to server content
- authorization credentials: typically name, password
- stateless: client must present authorization in *each* request
  - authorization: header line in each request
  - if no authorization: header, server refuses access, sends
    WWW authenticate:
    header line in response



Cookies: keeping "state" [RFC 2109]

- server-generated # , server-remembered #, later used for:
  - authentication
  - remembering user preferences, previous choices
- server sends "cookie" to client in response msg
  Set-cookie: 1678453
- client presents cookie in later requests
  cookie: 1678453



Conditional GET: client-side caching

- Goal: don't send object if client has up-to-date cached version
- client: specify date of cached copy in http request
  If-modified-since: <date>
- server: response contains no object if cached copy is up-to-date:
  HTTP/1.0 304 Not Modified