Web Services

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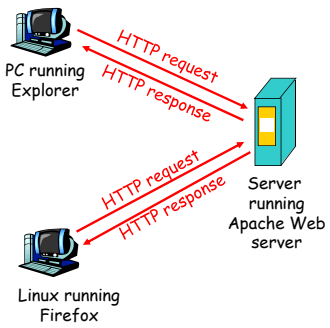
Web and HTTP

- Web: the Internet application for distributed publishing and viewing of content
- Client/server model
  - server: hosts published content and sends the content upon request
  - client: requests, receives, and displays content
- HTTP: the comm. protocol supporting the web
  - request/response format



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URLs

- Each web object managed by a server has a unique name called a URL (Universal Resource Locator)
- URL examples:
  - **`http://www.cs.rochester.edu:80/index.html`**
  - **`http://www.cs.rochester.edu/index.html`**
  - **`http://www.cs.rochester.edu`**
    - Identifies a file called **`index.html`**, managed by a Web server at **`www.cs.rochester.edu`** that is listening on port 80.
- Include an authority component (server) and page component

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Anatomy of an HTTP Transaction

```
unix> telnet www.rochester.edu 80      Client: open connection to server
Trying 128.151.57.101...               Telnet prints 3 lines to the terminal
Connected to www.rochester.edu.
Escape character is '^]'.
GET /index.html HTTP/1.1               Client: request line
host: www.rochester.edu                Client: required HTTP/1.1 HOST header
                                       Client: empty line terminates headers.
HTTP/1.1 200 OK                        Server: responds with web page
Date: Tue, 17 Apr 2012 15:48:32 GMT
Server: Apache
Transfer-Encoding: chunked
Content-Type: text/html
...                                    Lots of stuff
Connection closed by foreign host.     Server: closes connection
unix>                                  Client: closes connection and terminates
```

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HTTP Requests

- HTTP request is a *request line*, followed by zero or more *headers*
- Request line: **<method> <uri> <version>**
  - **<version>** is HTTP version of request (**HTTP/1.0** or **HTTP/1.1**)
  - **<uri>** is the full URL, or URL suffix (if the server is known).
  - **<method>**
    - **GET**: Retrieve content
      - Workhorse method (99% of requests)
    - **POST**: Retrieve dynamic content with arguments
      - Arguments for dynamic content are in the request body
    - **OPTIONS**: Get server or file attributes
    - **HEAD**: Like **GET** but no data in response body
    - … …
- Request headers: **<header name>: <header data>**
  - Provide additional information to the server.

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HTTP Responses

- HTTP response is a *response line* followed by zero or more *response headers*.
- Response line: **<version> <status code> <status msg>**
  - **<version>** is HTTP version of the response.
  - **<status code>** is numeric status.
  - **<status msg>** is corresponding English text.
    - 200 OK Request was handled without error
    - 301 Moved Provide alternate URL
    - 403 Forbidden Server lacks permission to access file
    - 404 Not found Server couldn't find the file.
- Response headers: **<header name>: <header data>**
  - Provide additional information about response
  - **Content-Type:** MIME type of content in response body.
  - **Content-Length:** Length of content in response body.

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How much to receive?

- Finish on close?
- Standard
  - Specify total length with content-length
  - Requires that program buffer entire message
- Chunked
  - Break into blocks
  - Prefix each block with number of bytes (Hex coded)

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Chunked Encoding Example

```
HTTP/1.1 200 OK\n
Date: Sun, 31 Oct 2010 20:47:48 GMT\n
Server: Apache/1.3.41 (Unix)\n
Keep-Alive: timeout=15, max=100\n
Connection: Keep-Alive\n
Transfer-Encoding: chunked\n
Content-Type: text/html\n
\r\n
d75\r\n
<html>
<head>
.<link href="http://www.cs.cmu.edu/style/calendar.css" rel="stylesheet"
type="text/css">
</head>
<body id="calendar_body">

<div id='calendar'><table width='100%'  border='0' cellpadding='0'
cellspacing='1' id='cal'>

 . . .
</body>
</html>
\r\n
0\r\n
\r\n
```

First Chunk: 0xd75 = 3445 bytes

Second Chunk: 0 bytes (indicates last chunk)

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HTTP Connection Persistency

TCP per-connection overhead:
- Connection establishment
- Congestion control: slow start

Non-persistent HTTP (1.0)
- At most one object is sent over a TCP connection.
- Pays TCP per-connection overhead for each object.

Persistent HTTP (1.1)
- Multiple objects can be sent over single TCP connection between the browser and web server.
- **`Connection: Keep-Alive`**

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HTTP Versions

- Major differences between HTTP/1.1 and HTTP/1.0
  - Connection persistency
  - HTTP/1.1 supports *chunked encoding*
    - Transfer-Encoding: chunked
  - HTTP/1.1 requires **HOST** header
    - **`Host: www.hosting-company.com`**
    - Makes it possible to host multiple websites at single Internet host
  - HTTP/1.1 adds additional support for caching

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Complexity of Web Server/Client Implementation

- Easy to implement a web server?
  - Tiny Web server described in text (226 lines of commented C code).
  - ~400 lines Java Web server on the web
  - Too simple for an assignment ☺
  - Complexity in performance, scalability, robustness, and security
- Web clients (browsers) are complex in user interactions

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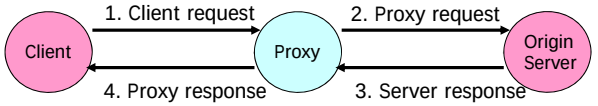
Proxies

- A *proxy* is an intermediary between a client and an *origin server*.
  - To the client, the proxy acts like a server.
  - To the server, the proxy acts like a client.



- Can perform useful functions as requests and responses pass by
  - Examples: Caching, logging, anonymization, filtering, transcoding

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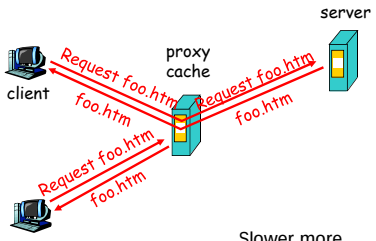
Web Proxy Caching

- Cache is installed and shared by users (university, company, residential ISP)
- Goal: satisfy client requests without involving the original server.
- Client sends all HTTP requests to proxy cache
  - object in cache: cache returns object
  - otherwise cache requests object from the original server, then returns object to client
- Benefits
  - bandwidth reduction
  - latency improvement



Fast inexpensive local network

Slower more expensive global network

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Cache Content Staleness

- Content providers lose direct control of cache content
  - retain some control through cached content staleness
- Is the cached page up-to-date?
  - using **`If-modified-since`** HTTP header.
  - removing pages that are too old.

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Web Prefetching

- Prefetch a web page before client makes access
  - Save latency, but not bandwidth
- Prefetching heuristics?
  - Hyperlinks in the current page (assume client may click some of them)
  - Predict future accesses based on past browsing history
- Where to do prefetching?
- Our study: web prefetching is not effective
  - Non-prefetchable dynamic applications are increasingly dominant
  - Benefits of history-based prefetching is diminished by proxy caching

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Mining of Cache Logs

- Web cache logs contain a wealth of information
  - List of who accessed what at when
- User privacy
- Aggregate statistics
  - Most popular web objects, distribution of web object popularity
  - General user access models (think time between accesses, pattern of page browsing sequence, …)
  - …

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Assignment #6

- Implement a web proxy server
- Allow concurrency through multi-threading
- Testing using telnet
- C and Java

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Security of Web Applications

- Interconnectedness exacerbates security threats
  - E.g., the buffer overflow problem would not have caused as much damage if it wasn't in a network server (fingerd)
- Effective countermeasure needs cooperation between architecture/operating-system/networking/programming-language

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Network Security Threat: Cross-Site Scripting

- Cross-site scripting:
  - duped to run script unintended by the original site
  - most significant vulnerability for web applications today
- Examples:
  - online message board FOOBAR displays user messages without much checking, attacker prepares a message that includes HTML tag and JavaScript code; a user who trusts FOOBAR views the message …
  - attacker embeds attack strings in machine names (due to Simon Weber)

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Disclaimer

These slides were adapted from the CMU course slides provided along with the textbook of "Computer Systems: A programmer's Perspective" by Bryant and O'Hallaron. The slides are intended for the sole purpose of teaching the computer organization course at the University of Rochester.

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