Last Time …

- The Transport Layer

Focus
- How does TCP share bandwidth?

Topics
- AIMD
- Slow Start
- Fast Retransmit / Fast Recovery

This Lecture

- HTTP and the Web (but not HTML)

Focus
- How do Web transfers work?

Topics
- HTTP, HTTP/1.1
- Performance Improvements
  - Protocol Latency
  - Caching
To view the URL http://server/page.html, the client makes a TCP connection to port 80 of the server, by its IP address, sends the HTTP request, receives the HTML for page.html as the response, repeats the process for inline images, and displays it.

HTTP Request/Response

Simple HTTP 1.0

- HTTP is a tiny, text-based language
- The GET method requests an object
- There are HTTP headers, like “Content-Length:”, etc.
- Try “telnet server 80” then “GET index.html HTTP/1.0”
  - Other methods: POST, HEAD, ... google for details
HTTP Request/Response in Action

- Problem is that:
  - Web pages are made up of many files.
    - Most are very small (< 10k).
  - Files are mapped to connections.
  - For each file:
    - Setup/Teardown
      - Time-Wait table bloat
      - 2RTT "first byte" latency
      - Slow Starts- AIMD Congestion Avoidance

- The goals of HTTP and TCP protocols are not aligned.
  - Implications

TCP Behavior for Short Connections Over Slow Networks

- RTT=70ms

It’s the RTT

- RTT=1ms
HTTP1.1: Persistent Connections

- Bright Idea: Use one TCP connection for multiple page downloads (or just HTTP methods)
- Q: What are the advantages?
- Q: What are the disadvantages?
  - Application layer multiplexing

HTTP/1.1

![Diagram](image.png)

Effect of Persistent HTTP

![Graph](image.png)

- Image size=2544
- Image size=45566
Caching

- It is faster and cheaper to get data that is closer to here than closer to there.
- “There” is the origin server. 2-5 RTT
- “Here” can be:
  - Local browser cache (file system) (1-10ms)
  - Client-side proxy (institutional proxy) (10-50)
  - Content-distribution network (CDN — “cloud” proxies) (50-100)
  - Server-side proxy (reverse proxy @ origin server) (2-5 RTT)

Browser Caches

- Bigger win: avoid repeated transfers of the same page
- Check local browser cache to see if we have the page
- GET with If-Modified-Since makes sure it’s up-to-date
- Q: What are the advantages and disadvantages?

Consistency and Caching Directives

- Key issue is knowing when cached data is fresh/stale
  - Otherwise many connections or the risk of staleness
- Browsers typically use heuristics
  - To reduce server connections and hence realize benefits
  - Check freshness once a “session” with GET If-Modified-Since and then assume it’s fresh the rest of the time
  - Possible to have inconsistent data.
- Caching directives provide hints
  - Expires: header is basically a time-to-live
  - Also indicate whether page is cacheable or not
Proxy Caches

- Insert further levels of caching for greater gain
- Share proxy caches between many users (not shown)
  - If I haven’t downloaded it recently, maybe you have
- Your browser has built-in support for this

Proxy Cache Effectiveness

Hit Rate Follows Request Rate

Figure 3: Cache hit rate for KOR as a function of cache size for a range of request rates.
Sharing, Not Locality, Drives Effectiveness

The Trends

- HTTP Objects are getting bigger
- But Less important

Next Steps?

- Different types of content (streaming media, XML)
- Content Delivery Networks (caching alternative)
- Security (for all those purchases)
Key Concepts

• HTTP and the Web is just a shim on top of TCP
  – Sufficient and enabled rapid adoption
  – Many "scalability" and performance issues now important