Web Proxies and Caching

CS 360 Internet Programming

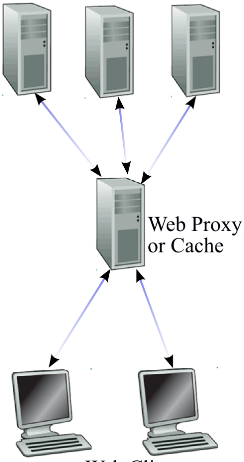
Daniel Zappala

Brigham Young University
Computer Science Department

Web Proxies

Proxy

- *an intermediary program that acts as both a server and a client for the purpose of forwarding requests*
- accepts requests from other clients and handles them either internally or by passing them on to other servers
- examples
  - caching responses
  - anonymizing requests
  - filtering content



Transparent Proxies

- transparent proxy: does not modify the request other than superficially
  - caches place identifying information in headers
- non-transparent proxy: may modify the request or response
  - anonymize request
  - filter content
  - compress response

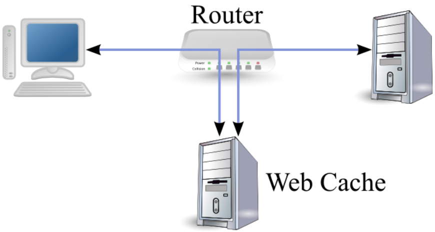
Anonymizing Requests

- anonymizing proxy hides IP address of client (client is not necessarily in the same organization)
    - may not hide the User-Agent header
    - may not drop cookies
- onion routing: setup a sequence of proxies along an unpredictable path, using encryption at each step
    - prevents eavesdropping
    - prevents traffic analysis
    - http://tor.eff.org/
    - http://en.wikipedia.org/wiki/Onion_Routing

Filtering Content

- examine application-level HTTP messages to block access to certain content
  - examine URL in the GET and compare to a blacklist of web sites
  - compare URL against a list of banned keywords: anonymizing searches often blocked
  - examine response and compare to a list of banned keywords
- BYU CS department uses DansGuardian dansguardian.org

Interception Proxies

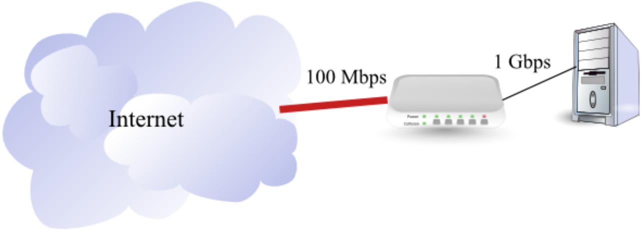


- all web traffic is diverted to the proxy, regardless of user preference

- diverting traffic
  1. router must examine TCP header on all packets
  2. a TCP packet going to port 80 is diverted to the proxy
  3. proxy must accept packets for any destination address going to port 80
  4. proxy then performs its functions – caching, filtering
- breaks the rules and layering of IP, but so do firewalls
- a reality for most major campuses and organizations

Web Caching

Motivation



- problem: bandwidth bottleneck at a server
- example
  - 100 Mbps connection
  - 100,000 KB typical web page size (with embedded content)
  - 125 requests per second
- buy more bandwidth
  - 1 Gbps (10 x more bandwidth)
  - 1250 requests per second
- hard to scale

Web Caching

- may return a cached object rather than contacting the origin web server
- need a cache consistency protocol - check whether objects in cache are up-to-date
- need a cache replacement algorithm - determine which objects to save when the cache is full
- hit rate determined by cache replacement algorithm, workload (object popularity, object size)

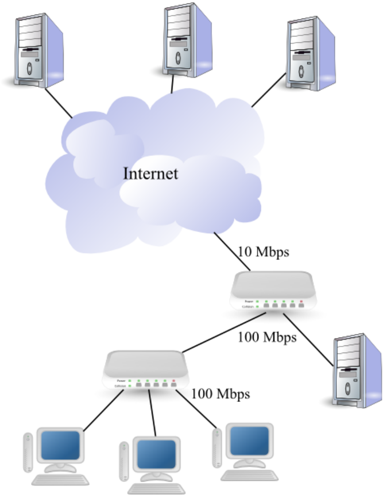
Reverse Proxies

- a cache that sits in front of web server
  - provide access to a server behind a firewall
  - centralize security concerns at one server
  - balance load among a set of back-end servers
  - provide one URL space for many different web sites
- can use Apache as either forward or reverse proxy

Benefits

Caching Benefits for Users

- faster download - web cache is usually on the local network, where there is more available bandwidth
- lower latency - shorter propagation delay for closer servers
- less congestion - fewer users sharing bandwidth, local networks are usually over-provisioned



Caching Benefits for Web Servers

- lower load on the server - can handle more users
- lower cost since it uses less bandwidth
- *but some servers want all the traffic because they receive revenue for ads on the site*
- solutions: no caching on ads, pay per click-through on ad instead of per visit, survey users like with traditional media

Caching Benefits for the Network

- the network as a whole
  - less traffic traversing the Internet, since it stays on local networks
  - reduces congestion - lower delay, lower packet loss
  - improves throughput - faster transfer times
- Internet Service Providers
  - each ISP pays its upstream provider based on its access link speed (bits per second) or the actual amount of traffic sent over the link
  - big incentive to provide web caches for their users - reduces the amount of traffic on the access link, which reduces their overall cost

What is Cacheable?

What is Cacheable?

- `Expires` header
  - date after which the response is considered stale and must be revalidated
  - cache does not need to revalidate item each time it has a cache hit
- `ETag` header
  - tag specific to a resource
  - decouples cache validation from expiration times, since clocks are not synchronized
  - cache uses `If-Match` header to check if the cached item is the same
- `Vary` header
  - lists fields that may vary in responses (e.g. language)
  - cache must check that these fields are the same in the request and the cached response

Server Control over Caching

- `Cache-Control` header specifies directives that MUST be obeyed by a cache regardless of its own algorithms
- restrictions on what is cacheable
  - `public`: item MAY be cached even if normally not cacheable (e.g. responses that have an Authorize field)
  - `private`: item MUST NOT be cached (intended for one user)
  - `no-cache`: MUST NOT be returned by a cache without validation
- restrictions on what may be stored
  - `no-store`: cache MUST NOT store any part of the request or response

Browser Control over Caching

- expiration mechanism
  - `max-age`: maximum age client wants from cache
  - `max-stale`: gives maximum staleness client wants from cache
  - `min-fresh`: client wants a response that will still be fresh for a minimum amount of time
- cache revalidation and reload
  - `end-to-end reload`: user wants item from origin server, caches MUST not return a cached copy
  - `only-if-cached`: user wants item if cached, otherwise an error
  - `must-revalidate`: server says response may be cached, but must be revalidated once it is stale
  - `proxy-revalidate`: does not apply to user's browser cache

How is Caching Done?

Caching Decisions

- check to see if requested object is in cache
- check if client headers allow item to be returned
- perform cache coherence checks
- perform cache replacement if needed

Cache Coherency

- cache must ensure that what is in the cache is consistent with what the server stores
- validating
  - `If-Modified-Since`: using Date
  - `If-Match`: using ETag
- when should the server validate?
  - use a TTL to indicate how much longer the cached response will be valid
  - based on `Expires`, `max-age` directive, or heuristic that examines last modification time and frequency of requests
- see `Squid Cache` FAQ for details on Squid coherence algorithm

Cache Replacement Algorithm

- many important factors
- access history: keep objects that are frequently accessed
- expiration time: remove objects that will expire soon
- time since last modification: keep objects that do not change frequently
- cost of fetching the resource: keep in cache if it was expensive to fetch
- cost of storing the resource: removing large objects frees a lot of space, but they are expensive to retain

Common Cache Replacement Algorithms

- Least Recently Used (LRU)
  - mark objects with time of last access
  - evict object that is least recently accessed
  - old and proven in many areas of CS
  - studies show it is not the best for web caching
- Least Frequently Used (LFU)
  - mark objects with how frequently accessed in a given period of time
  - evict object that is least frequently used
- Size of Object (SIZE): evict largest object
- Hyper-G: first LFU, then LRU, then largest
- Greedy-Dual Size
  - compute a utility value for each object
  - evict object with lowest utility
  - utility uses cost of fetching, size, age

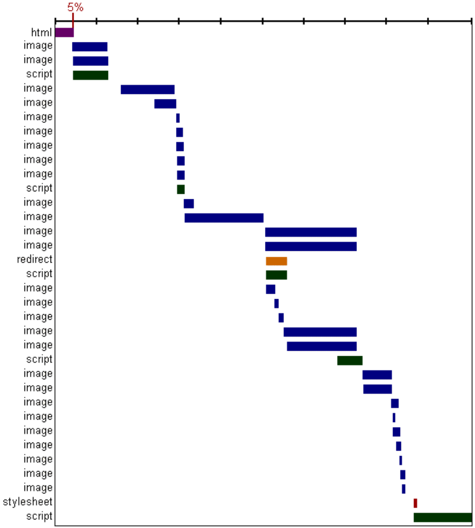
Cache Replacement Lessons

- *memory is cheap*: create a really large cache
- *lots of traffic isn't cacheable*
- *most algorithms are good enough*
- Squid uses LRU, Greedy-Dual Size, LFU with Dynamic Aging

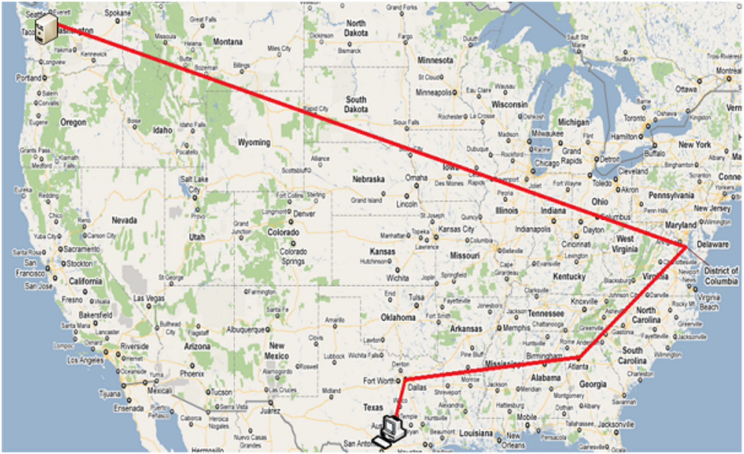
Content Delivery Networks

Web Site Performance

- Steve Souders (Yahoo, Google): 80% of web page download time is spent fetching embedded images and scripts



Latency



- want to avoid latency caused by long paths

Content Delivery Network

- replicate content at many caches, typically at the edge of the network
- use domain name of the CDN in your web pages
- client requests routed to a “nearby” server, generally through DNS, reducing loss and delay
- started with Akamai: `IEEE Internet Computing paper`
- see `Amazon CloudFront`