CSC2231: Akamai

http://www.cs.toronto.edu/~stefan/courses/csc2231/05au

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Administrivia

- Project proposals due today!!!
- No lecture on Monday:
  - Eat well!
- Shuffled the order of some lectures:
  - Next Thursday:
- No lecture on October 17th because of Cascon
Web Performance Techniques

• Four Common Categories
  – Web Transport Optimization
  – Server Scalability
  – Document Relocation
  – Browser Optimization
Web Performance Techniques

• **Four Common Categories**
  - Web Transport Optimization
    • HTTP1.1 (Persistent Connections), TCP tweaks
  - Server Scalability
    • Clusters, OS enhancements
  - Document Relocation
    • Web caching, prefetching
  - Browser Optimization
Benefits of Proxy Caching

• Proxy caching is the most commonly used method to improve Web performance
  – Duplicate requests to the same document served from the cache
  – Hits reduce latency, network utilization, and server load
  – Introduces problems:
    • Misses increase latency (extra hops)
    • cache consistency
Cache Consistency

- Fresh-enough is good-enough
- One writer, many readers
  - Most content changes slowly wrt # reads

- Cache consistency governed by standards
- “Expiration” based cache consistency
  - Expires timestamp on each object
  - Cache revalidates content beyond that time

- Why not callbacks?
Data Update Propagation

- **IBM’s Olympic Games website**
  - Back-end: database, content generation
  - Front-end: web caches (accelerators)

- **Cache consistency:**
  - Manager has callback list with \langle cache, object \rangle
  - Developer annotates objects with data dependencies

- **Graph of data->object dependencies**
  - Invalidate caches and proactive regeneration of objects
Multiple Caches

- Does it make sense to have caches upstream to local cache?
Multiple Caches

• Does it make sense to have caches upstream to local cache?
• Then, why do Internet servers make heavy use of reverse Web caches?
  – Amazon, Google
Content Distribution

- Lots of excitement?
- Akamai, Digital Island/Sandpiper, Speedera
- What is a Content Distribution Network (CDN)?
  - Outsourced caching and replication services
Cache Deployments

Where else?
Cache Deployments

[Diagram showing various cache deployments including Browser Cache, Proxy Cache, CDN, Reverse Proxy/Accelerator, and Web Server.]
Content Providers’ Advantages

• **CDN provider maintains networks and servers**
  – Capacity management

• **Sharing resources across a large number of sites**
  – Economy of scale
  – Control of content placement and routing

• **Protects content provider from unpredictable load bursts**

• **Communication between content provider and CDN network is not governed by standards**
  – Don’t even need to use HTTP
  – Can cache “uncacheable” documents
  – Can deploy alternative cache consistency
  – Can place requirements on content providers
CDNs’ Challenges
CDNs’ Challenges

• How to replicate content?
• Where to replicate content?
• How to find replicated content?
• How to choose among know replicas?
• How to direct clients towards replica?

• Akamai
How Akamai Works

• Clients fetch html document from primary server
  – E.g. fetch index.html from cnn.com

• URLs for replicated content are replaced in html
  – E.g. `<img src="http://cnn.com/af/x.gif">` replaced with `<img src="http://a73.g.akamaitech.net/7/23/cnn.com/af/x.gif">`

• Client is forced to resolve aXYZ.g.akamaitech.net hostname
How Akamai Works

- Root server gives NS record for akamai.net
- Akamai.net name server returns NS record for g.akamaitech.net
  - Name server chosen to be in region of client’s name server
  - TTL is large
- G.akamaitech.net nameserver choses server in region
  - Should try to chose server that has file in cache
  - TTL is small
How Akamai Works

cnn.com (content provider)  DNS root server

Get index.html

Get foo.jpg

1 2 3 4 11 12

5 6 7 8

9

10

Get /cnn.com/foo.jpg
Akamai – Subsequent Requests

End-user

1. Get index.html
2. cnn.com (content provider)
3. DNS root server
4. Akamai high-level DNS server
5. Akamai low-level DNS server
6. Closest Akamai server
7. Get cnn.com/foo.jpg

8. 9. 10.
TCP Mambo-Jambo

• **Bandwidth-delay product:**
  – Number of outstanding (i.e., in-flight or unacknowledged) packets cannot exceed the bandwidth-delay product

• **A 1Mbps link**
  – RTT: 1 sec, cannot have more than 128 KB outstanding
  – RTT: 100ms, cannot have more than 1280 KB outstanding
CDN’s Reduced Latency Benefits

- DNS round-trip
- TCP handshake
- ~8 RTTs to fill 1Mbps pipe
- Total: 128KB over 11 RTTs
- Coast-to-coast RTT: 60ms
- Toronto to Akamai RTT: 2-3ms
- Total RTT for filling-out pipe:
  - Without Akamai: 600ms
  - With Akamai: 30ms
Lets look at a study

- Zhang, Krishnamurthy and Wills
  - AT&T Labs
- Compared CDNs with each other
- Compared CDNs against non-CDN
Methodology

- **Selected a bunch of CDNs**
  - Akamai, Speedera, Digital Island
- **Selected a number of non-CDN sites for which good performance could be expected**
  - U.S. and international origin
  - U.S.: Amazon, Bloomberg, CNN, ESPN, MTV, NASA, Playboy, Sony, Yahoo
- **Selected a set of images of comparable size for each CDN and non-CDN site**
  - Compare apples to apples
- **Downloaded images from 24 NIMI machines**
Response Time Results (II)
Including DNS Lookup Time

Client Location: US  HTTP Option: Parallel-1.0

Cumulative Probability

Completion Time (DNS+Downloading) (seconds)

Adero
Akamai
Clearway
Digisle
Fasttide
Speedera
US Origin
Intl Origin

From Ken Birman’s slides

CSC2231: Internet Systems  Stefan Saroiu 2005
CDNs generally provide much shorter download time.
CDNs out-performed non-CDNs

• Why is this?
• Lets consider ability to pick good content servers…
• They compared time to download with a fixed IP address versus the IP address dynamically selected by the CDN for each download
  – Recall: short DNS TTLs
Effectiveness of DNS load balancing

From Ken Birman’s slides

CSC2231: Internet Systems

Stefan Saroiu 2005
Effectiveness of DNS load balancing

Black: longer download time
Blue: shorter download time, but total time longer because of DNS lookup
Green: same IP address chosen
Red: shorter total time

From Ken Birman’s slides
DNS load balancing not very effective

From Ken Birman’s slides
Discussion

- Networks are becoming bigger and faster
  - Last-mile is the REAL problem
- Do CDNs make any sense anymore?
Discussion

• **CDNs for large content**
  – Video?
Discussion

• **CDNs as insurance against \/. effect?**
  – Should we still use DNS-redirection for this?