Content Distribution

- How to distribute content without requiring centralized, heavy-duty servers?
- Examples:
  - Bittorrent
    - Peer-to-peer content distribution
  - Akamai
    - Content distribution service

Bottlenecks for Web Downloads

- 3 potential bottleneck locations:
  - The first mile
    - User’s access connection may be limited
  - The last mile
    - Link connecting server to Internet can get overloaded by too many requests
  - Peering points
    - ISPs have little motivation to provide high-capacity connectivity to their peers
- Idea: replication can address the 2nd and 3rd issues
  - Only end-user can solve the 1st one
- Content Distribution Networks
  - Systems that provide such replication
**CDN Infrastructure**

- Backend servers
- Geographically distributed surrogate servers
- Redirectors
- Clients

**Content Distribution vs Caching**

- Explicitly manage cache content
  - Sell as service to website owners for performance
- “Push” content to caches at major Internet providers
  - Make content appear “nearby” (low latency) no matter where the request is located
- Change cache content when necessary
  - Operates as a proxy cache to refresh content
Akamai Content Distribution Network

http://www.akamai.com/html/about/facts_figures.html

- 216,000 servers in 120 countries within nearly 1,500 networks
  - 85% of the world's Internet users have a single "network hop" to an Akamai server
- Delivers 15 - 20% of all Web traffic
  - Web traffic at times reaching more than 30 Terabits/sec
  - 3 trillion daily Internet interactions

Akamai Customer Base

- Akamai is Trusted by:
  - One out of every three Global 500® companies (Source: List compiled by Fortune Magazine)
  - The top 30 media & entertainment companies
  - All 20 top global e-commerce sites
  - Ninety-six of the top 100 online U.S. retailers (Source: Internet Retailer Magazine)
  - All branches of the U.S. military
  - More than 150 of the world's leading news portals
  - 18 of the top 20 world's largest asset managers (Source: Tower's Watson)
  - 12 of the top 20 world's largest insurers (Source: AM Best)
  - 8 of the top 10 world's largest FinTech firms (Source: American Banker)
  - Nine of the top 10 largest newspapers
  - Eight of top 10 online publishers
  - Seven out of 15 top social media companies worldwide
  - Three of the top 5 semiconductor companies
  - Thirteen of the top 15 largest auto manufacturers
  - Nine of the top 10 global pharmaceutical companies
  - Six of the top seven computer manufacturers
  - All of the top anti-virus companies
  - Four of the top five online auction companies
  - All major U.S. sports leagues
**Akamai CDN Example**

**Akamai Content Types**

- **Static (HTML, images, PDF, etc.)**
  - Expiration time (0 – infinity) assigned by customer
  - On-demand cache invalidation available to customer
  - Special features (authenticated access, transfer encodings, etc.)

- **Dynamic**
  - Assembles cacheable and non-cacheable elements of page at cache (contacts origin only for non-cacheable)

- **Streaming**
  - Uses redundant streams and jitter-control to ensure quality playback
Web Site Redirection to Akamai

- DNS CNAME aliases
  - e.g., images.pcworld.com
    CNAME=images.pcworld.com.edgesuite.net

- Modified URLs (“Akamized”)
  - Prefix with domain name in Akamai
  - e.g., http://a1694.g.akamai.net/8675/images.pcworld.com..
**Akamai DNS Processing**

- QUERY: images.pcworld.com
  - REPLY: 128.109.247.9
- QUERY: images.pcworld.com.edgesuite.net
  - REPLY: adns1.akamai.net (CNAME)
- QUERY: a1694.g.akamai.net
  - REPLY: za.akamaitech.net (NS) TTL= 48 hours
  - REPLY: n0g.akamaitech.net (NS) TTL= 30 – 60 minutes
  - REPLY: 128.109.247.9 (A) TTL= 20 seconds

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**Akamai Network Operations Center**

- Monitors all proxy servers and end-to-end conditions on paths from 1000s of network locations to servers
- DNS servers updated with new loads and maps every few seconds

- Monitored conditions
  - Server load and operational status
  - Routing topology
  - Latency and packet losses per route
  - Available bandwidth per route

- Lots of geographically-distributed clients
  - 140 Planetlab nodes around the world
  - US, Canada, Europe, Asia, S. America, Australia

- Probe for 15 Akamai customers
  - Yahoo, CNN, Amazon, AOL, NY Times, Apple, Monster, FOX News, MSN, PCWorld

- Frequent probing
  - Every 20 seconds, send a DNS request for an Akamai customer
  - Experiments run for several days

How Much Server Diversity Exists?

Yahoo!

- Larger network distance – larger # of edge servers
  - Asia, S. America, Purdue U., Columbia U.
  - Low server diversity: share network with edge servers

A. Su, et. al., "Drafting Behind Akamai (Travelocity-Based Detouring)", SIGCOMM 2006
Server Diversity per Customer & User Location

- All clients show large server diversity for at least one customer
  - Amazon, Yahoo, NY Times

Redirection Dynamics

- Low-level Akamai DNS servers may not point to a new set of edge servers after each timeout
  - Berkeley – 50% of redirections shorter than 40 seconds
  - Korea, Brazil – median redirection time is 4-6 minutes!
Akamai End-User Mapping (2015)

- **CDN Issue:**
  - When LDNS (local recursive resolver) is not close to client, using DNS for server selection will not be optimal

- **One fix: edns-client-subnet extension**
  - LDNS passes a prefix of the client’s IP address to authoritative name server

- **This experience paper from Akamai:**
  - Measures performance improvements seen by clients after Akamai adoption

- **Highlights:**
  - 8x decrease in mapping distance
  - 2x decrease in RTT and download time
  - 30% improvement in time-to-first-byte

- **Challenges: greater DNS query rates (per client-IP block)**