Motivation

- Serving web content from one location presents problems
  - Scalability
  - Reliability
  - Performance

- “Flash crowd” problem
  - What if everyone comes to your site at once?

- Cache content and serve requests from multiple servers at the network edge (close to the user)
  - Reduce demand on site’s infrastructure
  - Provide faster service to users
  - Content comes from nearby servers

Focus on Content

- Computing is still done by the site host’s server(s)
- Offload the static parts—they often make up the bulk of the bytes:
  - Images
  - Video
  - CSS files
  - Static pages
Load Balancing

Increase capacity at the server.
Internet connectivity can be a bottleneck ... + latency from client to server.

Multihoming

• Get network links from multiple ISPs
• Server has one IP address but multiple links
• Announce address to upstream routers via BGP:
  Provides clients with a choice of routes and fault tolerance for a server’s ISP going down

Mirroring (Replication)

• Synchronize multiple servers
• Use multiple ISPs: location-based load balancing, ISP & server fault tolerance

Improving scalability, availability, & performance

• Scalability
  – Mirror (replicate) servers for load balancing among multiple servers
  – Multiple ISPs if network congestion is a concern

• Availability
  – Replicate servers
  – Multiple data centers & ISPs

• Performance
  – Cache content and serve requests from multiple servers at the network edge (close to the user)
  – Reduce demand on site’s infrastructure
  – Provide faster service to users
  – Content comes from nearby servers

But these approaches have problems!

• Local balancing
  – Data center or ISP can fail

• Multihoming
  – IP protocols (BGP) are often not quick to find new routes

• Mirroring at multiple sites
  – Synchronization can be difficult

• Proxy servers
  – Typically a client-side solution
  – Low cache hit rates

All require extra capacity and extra capital costs
Akamai Distributed Caching

- Company evolved from MIT research
- “Invent a better way to deliver Internet content”
- Tackle the “flash crowd” problem

Akamai runs on >240,000+ servers in >1,700 networks across >130 countries
- Delivers 15-30% of all web traffic
  - reaching over 30 Terabits per second

Akamai’s goal

Try to serve clients from servers likely to have the content
- Nearest: lowest round-trip time
- Available: server that is not too loaded
- Likely: server that is likely to have the data

Akamai Overlay Network

- The Internet is a collection of many autonomous networks
  - Connectivity is based on business decisions
  - Peering agreements, not performance
  - An ISP’s top performance incentives are:
    - Last-mile connectivity to end users
    - Connectivity to servers on the ISP
- Akamai’s Overlay network
  - Collection of caching servers at many, many ISPs
  - All know about each other

Overlay Network

1. Domain name lookup
   - Translated by mapping system to an edge server that can serve the content
   - Use custom DNS servers
     - Take requestor’s address into account to find the nearest edge
2. Browser sends request to the given edge server
   - Edge server may be able to serve content from its cache
   - May need to contact the origin server via the transport system

Mapping: Domain Name Lookup

- Akamai uses Dynamic DNS servers
- Resolve a host name based on:
  - user location (minimize network distance)
  - server health
  - server load
  - network status
  - load balancing
- Try to find an edge server at the customer’s ISP

Akamai collects network performance data

- Map network topology
  - Based on BGP and traceroute information
  - Estimate hops and transit time
- Content servers report their load to a monitoring application
- Monitoring app publishes load reports to a local (Akamai) DNS server
- Akamai DNS server determines which IP addresses to return when resolving names
- Load shedding:
  - If servers get too loaded, the DNS server will not respond with those addresses
Benefits of an overlay network CDN

1. Caching
   - Goal: Increase hit rate on edge servers
     - Reduce hits on origin servers
   - Static content can be served from caches
     - Dynamic content still goes back to the origin
   - Two-level caching
     - If edge servers don’t have the data, check with parent servers

1. Caching: types of content
   - Static content
     - Cached depending on original site’s requirements (never to forever)
   - Dynamic content
     - Caching proxies cannot do this
       - Akamai uses Edge Side Includes technology (www.esi.org)
       - Assemblies dynamic content on edge servers
       - Page is broken into fragments with independent caching properties
       - Assembled on demand
   - Streaming media
     - Live stream is sent to an entry-point server in the Akamai network
     - Stream is delivered from the entry-point server to multiple edge servers
     - Edge servers serve content to end users.

1. Routing
   - Route to parent servers or origin via the overlay network
   - Routing decision factors:
     - measured latency
     - packet loss
     - available bandwidth
   - Results in ranked list of alternate paths from edge to origin
   - Each intermediate node acts as a forwarder
     - Keep TCP connections active for efficiency

3. Security
   - High capacity
     - Overwhelm DDoS attacks
   - Expertise
     - Maintain systems and software
   - Extra security software
     - Hardened network stack
     - Detect & defend attacks
   - Shield the origin
     - Attacks hit the CDN, not the origin

Other Things CDNs Do
Signed URLs in Amazon CloudFront

- **Example: Amazon CloudFront CDN**
  - Similar in concept to Akamai
  - Requests for content are routed to the nearest edge location
  - Cached content with original located at origin servers
  - Integrates with back-end Amazon services
- **Private content: provide special URLs for restricted content**
  - Control access to content via a signed URL
  - URL contains:
    - policy or reference to a policy
    - Signature = encrypted hash
  - URL cannot be modified
  - Policies include:
    - Validity: start time & expiration time
    - Range of IP addresses that are allowed to access the object

Limelight Orchestrate™

- **Focus on video distribution and content management**
- **Video transcoding**
  - Encode video to a variety of formats
  - Support playback on various devices: different formats & bitrates
- **Ad insertion**
  - Integrate with ad servers (DoubleClick, LiveRail, Tremor, YuMe)
  - Pre-roll, post-roll, mid-roll, overlay, etc.

Limelight Orchestrate™ Transcoding

![Diagram of transcoding process]

Server-side Video Ad Insertion

**Example: Limelight Reach Ads**

![Diagram of ad insertion process]