HTTP Caching & Cache-Busting for Content Publishers

Michael J. Radwin
http://public.yahoo.com/~radwin/

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Large web sites need to provide a personalized experience while keeping page-download times and bandwidth costs low. Radwin discusses when to use and when to avoid HTTP caching, and how to employ cache-busting techniques most effectively. Radwin also explains the top 5 caching and cache-busting techniques for content publishers.

Agenda

- HTTP in 3 minutes
- Caching concepts
  - Hit, Miss, Revalidation
- 5 techniques for caching and cache-busting
- Not covered in this talk
  - Proxy deployment
  - HTTP acceleration (a k a reverse proxies)
  - Database query results caching

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YAHOO!

Motivation:

Publishers have a lot of web content

HTML, images, Flash, movies

Speed is important part of user experience

Bandwidth is expensive

Use what you need, but avoid unnecessary extra

Personalization differentiates

Show timely data (stock quotes, news stories)

Get accurate advertising statistics

Protect sensitive info (e-mail, account balances)

Not covered:

Proxy deployment is an interesting subject and deserves an entire lecture by itself

Configuring proxy cache servers (i.e. Squid)

Configuring browsers to use proxy caches

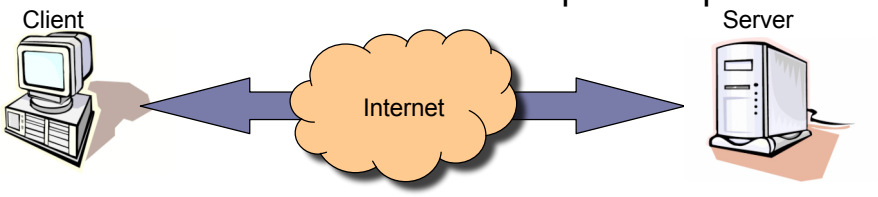
Transparent/interception proxy caching

Intercache protocols (ICP, HTCP)

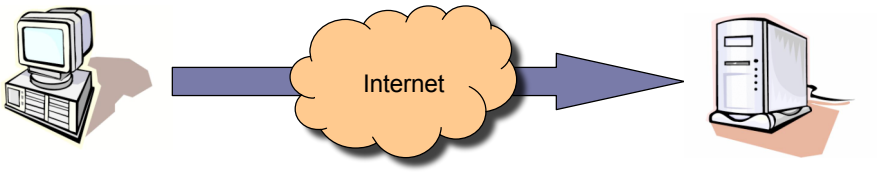
HTTP and Proxy Review

HTTP: Simple and elegant

1. Client connects to www.example.com port 80



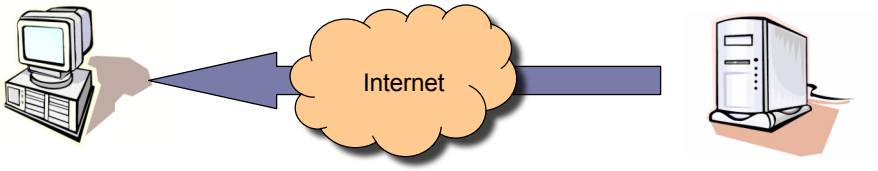
2. Client sends GET request



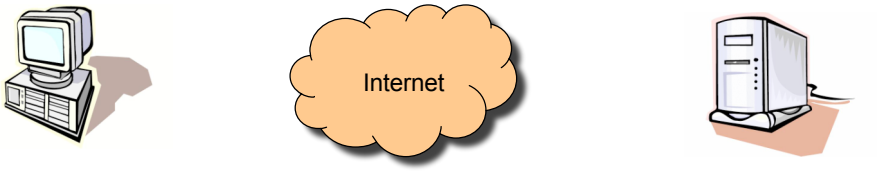
YAHOO!

HTTP: Simple and elegant

3. Server sends response



4. Client closes connection



YAHOO!

HTTP example

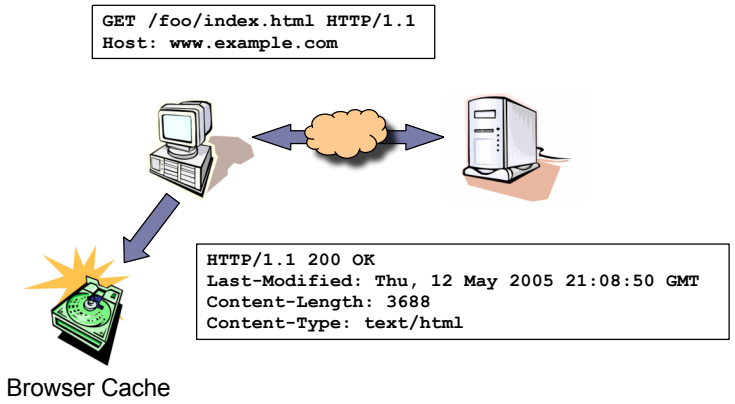
```
mradwin@machshav:~$ telnet www.example.com 80
Trying 192.168.37.203...
Connected to w6.example.com.
Escape character is '^]'.
GET /foo/index.html HTTP/1.1
Host: www.example.com

HTTP/1.1 200 OK
Date: Wed, 28 Jul 2004 23:36:12 GMT
Last-Modified: Thu, 12 May 2005 21:08:50 GMT
Content-Length: 3688
Connection: close
Content-Type: text/html

<html><head>
<title>Hello World</title>
...
```


YAHOO!

Browsers use private caches



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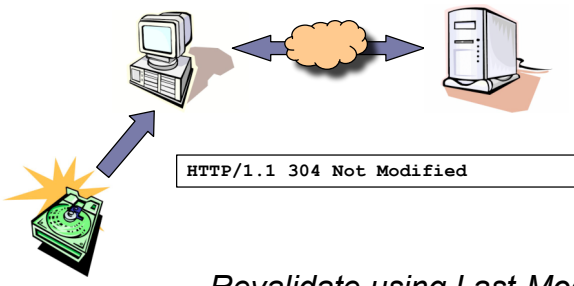
YAHOO!

Client stores copy of **http://www.example.com/foo/index.html** on its hard disk with timestamp.

Revalidation (Conditional GET)

```
GET /foo/index.html HTTP/1.1
Host: www.example.com
If-Modified-Since: Thu, 12 May 2005 21:08:50 GMT
```



```
HTTP/1.1 304 Not Modified
```

Revalidate using Last-Modified time

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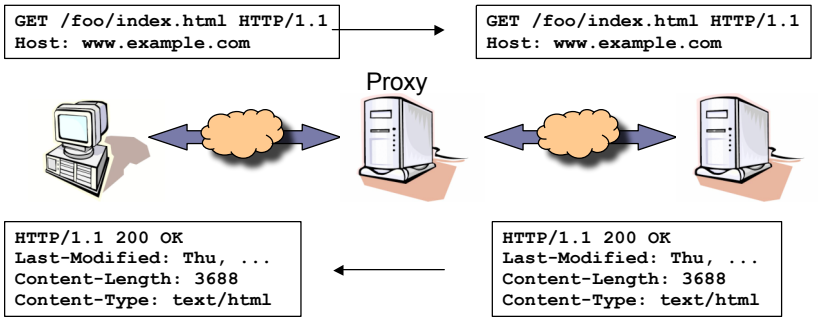
YAHOO!

The presence of If-Modified-Since header is what makes this a Conditional GET. Sometimes called an "IMS GET".

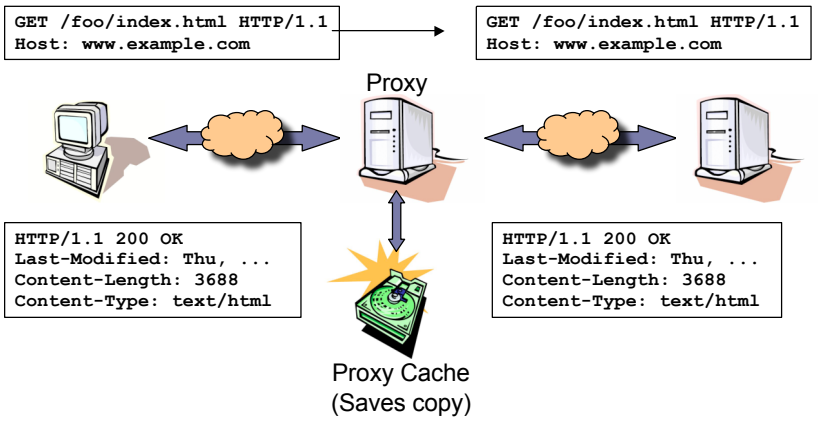
If content had actually changed, server would simply reply with a 200 OK and send full content.

Non-Caching Proxy



YAHOO!

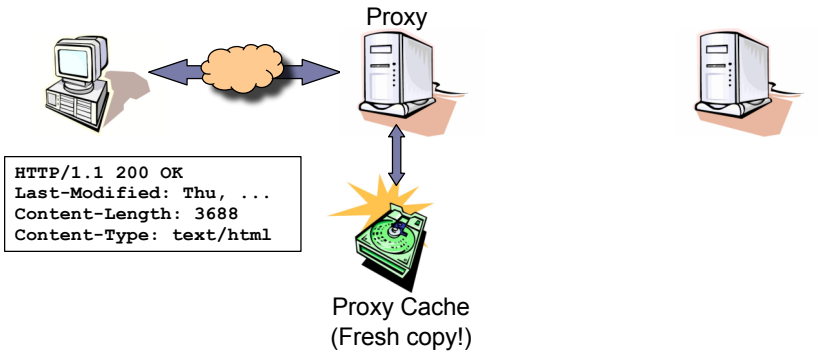
Caching Proxy: Miss



YAHOO!

Caching Proxy: Hit

```
GET /foo/index.html HTTP/1.1
Host: www.example.com
```

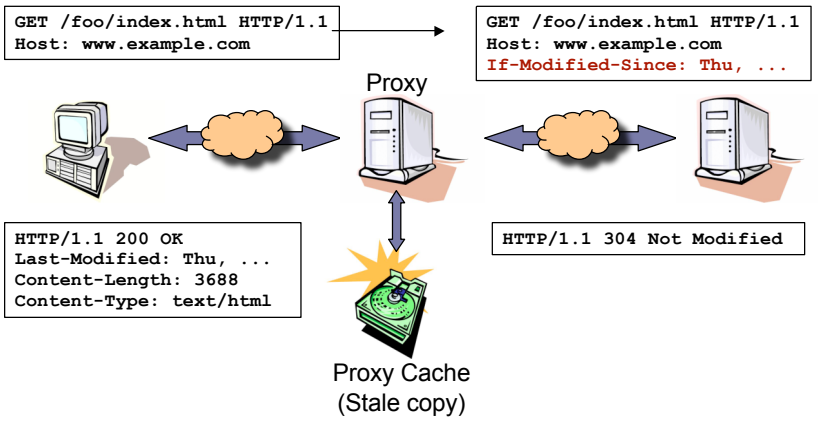



```
HTTP/1.1 200 OK
Last-Modified: Thu, ...
Content-Length: 3688
Content-Type: text/html
```

Proxy Cache
(Fresh copy!)

YAHOO!

Caching Proxy: Revalidation



YAHOO!

Top 5 Caching Techniques

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Assumptions about content types

Rate of change once published		
Frequently	*Occasionally*	*Rarely/Never*
HTML	CSS	Images
	JavaScript	Flash
		PDF

Dynamic Content	Static Content
Personalized	Same for everyone

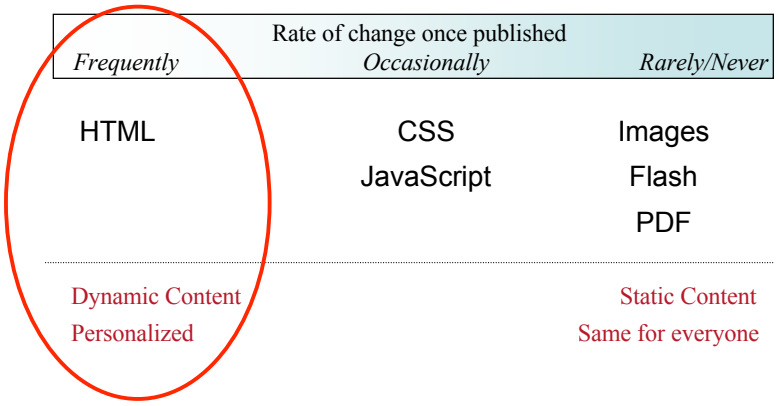
YAHOO!

Top 5 techniques for publishers

1. Use `Cache-Control: private` for personalized content
2. Implement “Images Never Expire” policy
3. Use a cookie-free TLD for static content
4. Use Apache defaults for occasionally-changing static content
5. Use random tags in URL for accurate hit metering or very sensitive content

YAHOO!

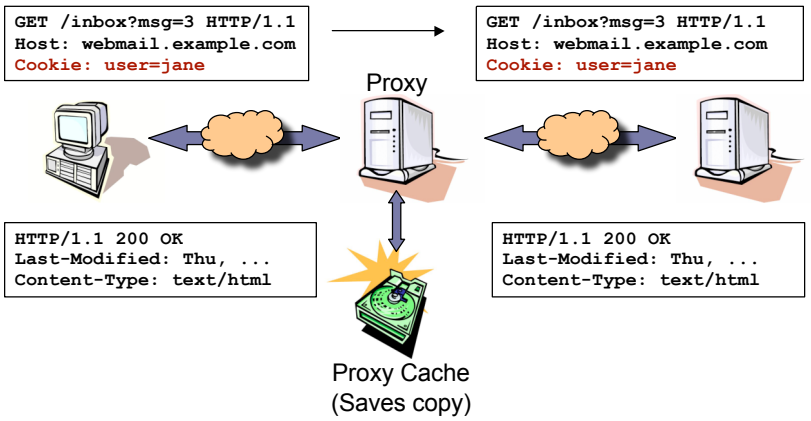
1. `Cache-Control: private` for personalized content



YAHOO!

Bad Caching: Jane's 1st visit

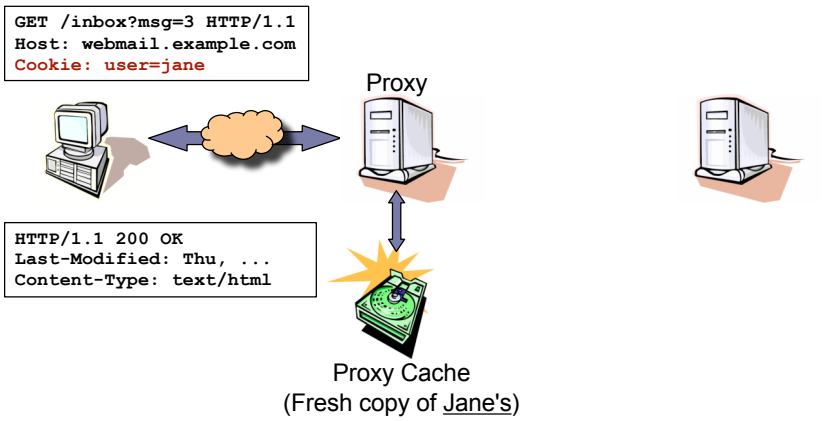
- The URL isn't all that matters



YAHOO!

Bad Caching: Jane's 2nd visit

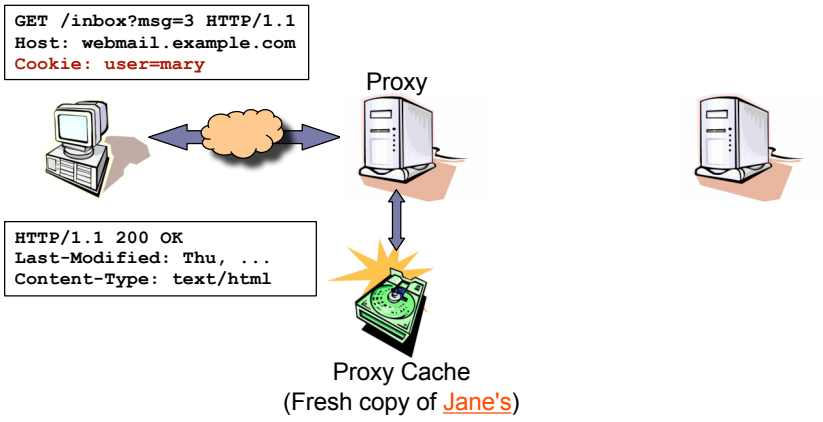
- Jane sees same message upon return



YAHOO!

Bad Caching: Mary's visit

- Witness a false positive cache hit



YAHOO!

What's cacheable?

- HTTP/1.1 allows caching anything by default
  - Unless overridden with `Cache-Control` header
- In practice, most caches avoid anything with
  - `Cache-Control/Pragma` header
  - `Cookie/Set-Cookie` header
  - `WWW-Authenticate/Authorization` header
  - `POST/PUT` method
  - `302/307` status code (redirects)
  - SSL content

YAHOO!

"13.4 Response Cacheability

Unless specifically constrained by a cache-control (section 14.9) directive, a caching system MAY always store a successful response (see section 13.8) as a cache entry, MAY return it without validation if it is fresh, and MAY return it after successful validation. If there is neither a cache validator nor an explicit expiration time associated with a response, we do not expect it to be cached, but certain caches MAY violate this expectation (for example, when little or no network connectivity is available). A client can usually detect that such a response was taken from a cache by comparing the Date header to the current time."

Cache-Control: private

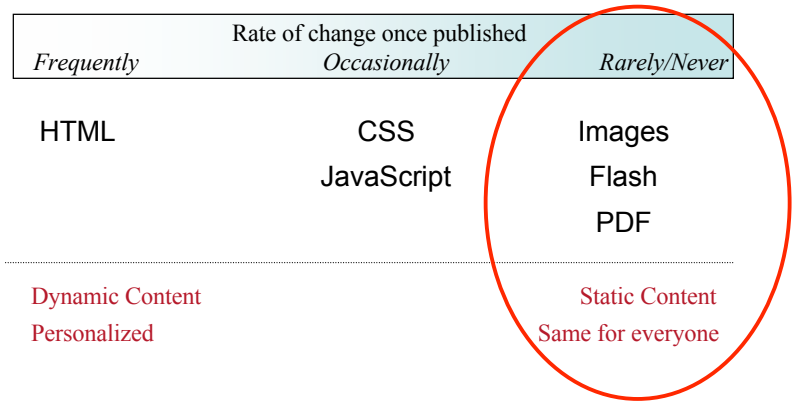
- Shared caches bad for shared content
  - Mary shouldn't be able to read Jane's mail
- Private caches perfectly OK
  - Speed up web browsing experience
- Avoid personalization leakage with single line in httpd.conf or .htaccess

```
Header set Cache-Control private
```


YAHOO!

Note that HTTP/1.0 proxies aren't expected to understand Cache-Control header. If you're really concerned about user information leakage and there's a possibility that your users are behind HTTP/1.0 proxies, use technique #5 (random strings in the URL).

2. “Images Never Expire” policy



YAHOO!

“Images Never Expire” Policy

- Dictate that images (icons, logos) once published never change
  - Set `Expires` header 10 years in the future
- Use new names for new versions
  - http://us.yimg.com/i/new.gif
  - http://us.yimg.com/i/new2.gif
- Tradeoffs
  - More difficult for designers
  - Faster user experience, bandwidth savings

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YAHOO!

Pushing images to a separate server typically means that designers can’t use 1-click publishing solutions such as Microsoft Frontpage.

Imgs Never Expire: mod_expires

```
# Works with both HTTP/1.0 and HTTP/1.1
# (10*365*24*60*60) = 315360000 seconds
ExpiresActive On
ExpiresByType image/gif A315360000
ExpiresByType image/jpeg A315360000
ExpiresByType image/png A315360000
```

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YAHOO!

24 * 60 * 60 * 365 * 10 = 315360000 seconds in ten years.

You may wish to add other mime types such as application/x-shockwave-flash

Imgs Never Expire: mod_headers

```
# Works with HTTP/1.1 only
<FilesMatch "\.(gif|jpe?g|png)$">
  Header set Cache-Control \
    "max-age=315360000"
</FilesMatch>
# Works with both HTTP/1.0 and HTTP/1.1
<FilesMatch "\.(gif|jpe?g|png)$">
  Header set Expires \
    "Mon, 28 Jul 2014 23:30:00 GMT"
</FilesMatch>
```


YAHOO!

You may wish to add other file extensions such as swf

Cache-Control is preferred for HTTP/1.1

Expires is for compatibility with HTTP/1.0 clients and proxies

When both headers are present, HTTP/1.1 clients typically prefer the Cache-Control header

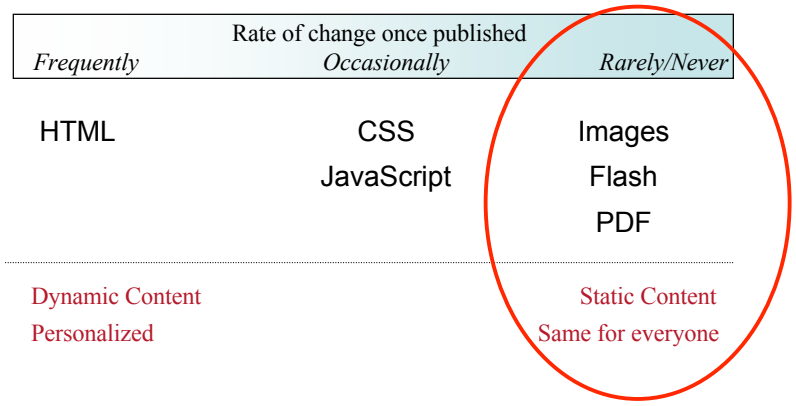
mod_images_never_expire

```
/* Enforce policy with module that runs at URI translation hook */
static int translate_imgexpire(request_rec *r) {
  const char *ext;
  if ((ext = strrchr(r->uri, '.')) != NULL) {
    if (strcasecmp(ext,".gif") == 0 || strcasecmp(ext,".jpg") == 0 ||
        strcasecmp(ext,".png") == 0 || strcasecmp(ext,".jpeg") == 0) {
      if (ap_table_get(r->headers_in,"If-Modified-Since") != NULL ||
          ap_table_get(r->headers_in,"If-None-Match") != NULL) {
        /* Don't bother checking filesystem, just hand back a 304 */
        return HTTP_NOT_MODIFIED;
      }
    }
  }
  return DECLINED;
}
```


YAHOO!

Also http://use.perl.org/~geoff/journal/22049

3. Cookie-free static content



YAHOO!

Use a cookie-free Top Level Domain for static content

- For maximum efficiency use 2 domains
  - `www.example.com` for dynamic HTML
  - `static.example.net` for images
- Many proxies won't cache `Cookie` requests
  - But: multimedia is never personalized
  - Cookies irrelevant for images

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YAHOO!

static.example.com won't cut it, because many cookies will be issued with "domain=.example.com". Unless you're 100% sure you'll only issue cookies with "domain=www.example.com", you'll need to use a completely different TLD. Yahoo!, for example, uses yahoo.com for dynamic HTML content and yimg.com for images and other static content.

Typical GET request w/Cookies

```
GET /i/foo/bar/quux.gif HTTP/1.1
Host: www.example.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.0; en-US; rv:1.7) Gecko/20040707
    Firefox/0.8
Accept: application/x-shockwave-
    flash,text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.
    8,video/x-mng,image/png,image/jpeg,image/gif;q=0.2,*/*;q=0.1
Cookie: U=mt=vtC1tp2MhYv9RL5BlpxYRFN_P8DpMJoamllEcA--&ux=IIr.AB&un=42vnticvufc8v;
    brandflash=1; B=amfco1503sgp8&b=2; F=a=NC184LcsvfX96G.JR27qSjCHu7bII3s.
    tXa44psMLliFtVoJB_m5wecWY_.7&b=K1It; LYC=l_v=2&l_lv=7&l_l=h03m8d50c8bo
    &l_s=3yu2qxz5zvwquwwuzv22wrwr5t3w1zsr&l_lid=14rsb76&l_r=a8&l_um=1_0_1_0_0;
    GTSessionID835990899023=8359908990234064 5635; Y=v=1&n=6eecgejj7012f
    &l=h03m8d50c8bo/o&p=m012o33013000007&jb=16|47|&r=a8&lg=us&intl=us&np=1;
    PROMO=SOURCE=fp5; YGCV=d=; T=z=iTu.ABiZD/AB6dPWoqXibIcTzc0BjY3TzI3NTY0MzQ-
    &a=YAE&sk=DAAwRz5HlDUN2T&d=c2wBT0RBekFURXdPRFV3TWpFek5ETS0BYQFZQUUBb2sBWlcwLQF0aXABW
    UhaTVBBAXp6AWlUdS5BQmdXQQ--&af=QUFBQ0FDQURCOUFIQUJBQ0FEQUtBTE
    FNSDAmdHM9MTA5MDE4NDQxOCZwcz11OG83MUVYcTYxOVouT2Ftc1ZFZUhBLS0-;
    LYS=l_fh=0&l_vo=myla; PA=p0=dg13DX4Ndgk-&p1=6L5qmg--&e=xMv.AB;
    YP.us=v=2&m=addr&d=1525+S+Robertson+Blvd%01Los+Angeles%01CA%0190035-
    4231%014480%0134.051590%01-118.384342%019%01a%0190035
Referer: http://www.example.com/foo/bar.php?abc=123&def=456
Accept-Language: en-us,en;q=0.7,he;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
```

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Since a Cookie header is sent, some proxies will refuse to cache the response.

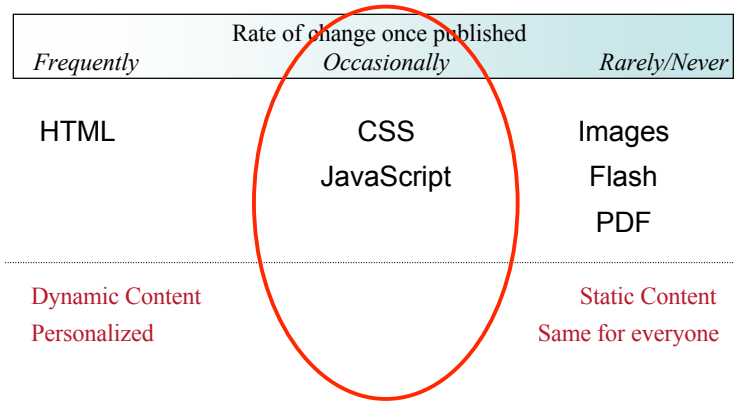
Same request, no Cookies

```
GET /i/foo/bar/quux.gif HTTP/1.1
Host: static.example.net
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.0; en-US; rv:1.7) Gecko/20040707
    Firefox/0.8
Accept: application/x-shockwave-
    flash,text/xml,application/xml,application/xhtml+xml,text/html;q=0.9,text/plain;q=0.
    8,video/x-mng,image/png,image/jpeg,image/gif;q=0.2,*/*;q=0.1
Referer: http://www.example.com/foo/bar.php?abc=123&def=456
Accept-Language: en-us,en;q=0.7,he;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
```

- Bonus: much smaller GET request
  - Dial-up MTU size 576 bytes, PPPoE 1492
  - 1450 bytes reduced to 550

YAHOO!

4. Apache defaults for static, occasionally-changing content



YAHOO!

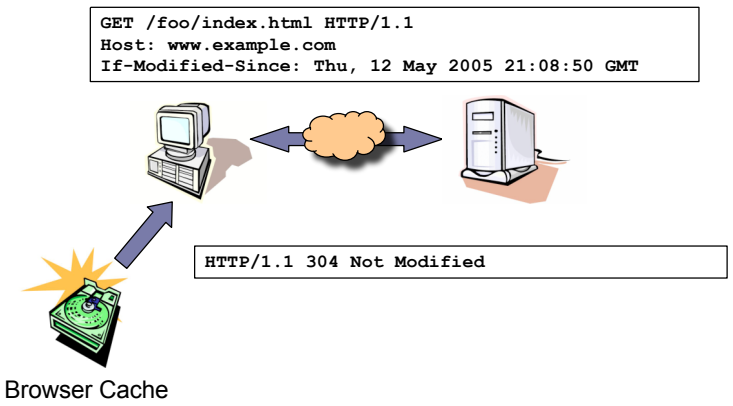
Revalidation works well

- Apache handles revalidation for static content
  - Browser sends `If-Modified-Since` request
  - Server replies with short `304 Not Modified`
  - No special configuration needed
- Use if you can't predict when content will change
  - Page designers can change immediately
  - No renaming necessary
- Cost: extra HTTP transaction for `304`
  - Smaller with `Keep-Alive`, but large sites disable

YAHOO!

Each HTTP request has some latency. When you disable Keep-Alive (as any large site typically must do to scale), each HTTP request requires a full 3-way TCP handshake. The handshake latency can be perceptible, especially on a slow connection such as a 56k modem.

Successful revalidation



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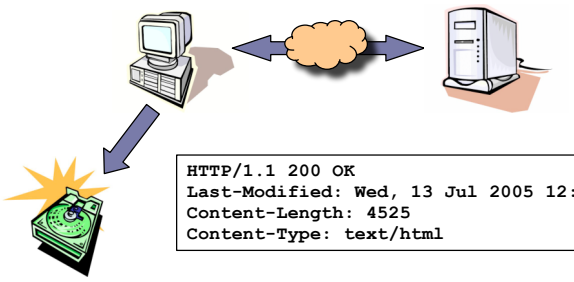
YAHOO!

Apache simply stat()s the file and compares the timestamp to the If-Modified-Since timestamp. If the file's timestamp is less than or equal to the If-Modified-Since header, it returns 304 Not Modified.

Updated content

```
GET /foo/index.html HTTP/1.1
Host: www.example.com
If-Modified-Since: Thu, 12 May 2005 21:08:50 GMT
```



```
HTTP/1.1 200 OK
Last-Modified: Wed, 13 Jul 2005 12:57:22 GMT
Content-Length: 4525
Content-Type: text/html
```

Browser Cache

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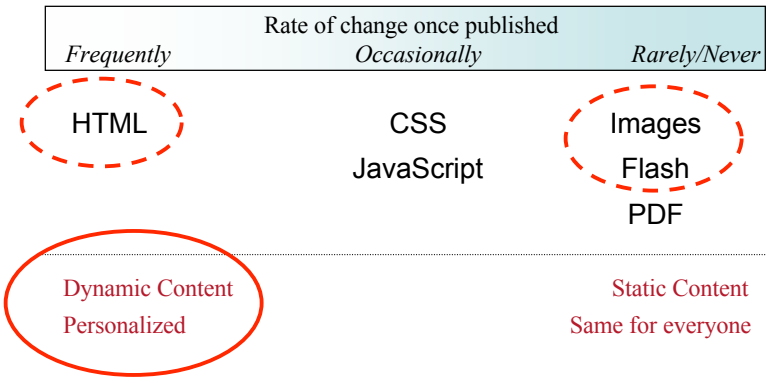
YAHOO!

Content has been modified. Client tries to revalidate again, but revalidation fails because URI has been updated. Apache returns 200 OK with full content.

5. URL Tags for sensitive content, hit metering



YAHOO!

URL Tag technique

- Idea
  - Convert public shared proxy caches into private caches
  - Without breaking real private caches
- Implementation: pretty simple
  - Assign a per-user URL tag
  - No two users use same tag
  - Users never see each other's content

YAHOO!

URL Tag example

- Goal: accurate advertising statistics
- Do you trust proxies?
  - Send `Cache-Control: must-revalidate`
  - Count `304 Not Modified` log entries as hits
- If you don't trust 'em
  - Ask client to fetch tagged image URL
  - Return `302` to highly cacheable image file
  - Count `302`s as hits
  - Don't bother to look at cacheable server log

YAHOO!

Hit-metering for ads (1)

```
<script type="text/javascript">
var r = Math.random();
var t = new Date();
document.write("<img width='109' height='52'
  src='http://ads.example.com/ad/foo/bar.gif?t="
  + t.getTime() + ";r=" + r + "'>");
</script>
<noscript>
<img width="109" height="52" src=
  "http://ads.example.com/ad/foo/bar.gif?js=0">
</noscript>
```

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No, this is not RFC 2227, which uses headers like "Connection: meter" and "Meter: count=1/0"

Hit-metering for ads (2)

```
GET /ad/foo/bar.gif?t=1090538707;r=0.510772917234983 HTTP/1.1
Host: ads.example.com
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.0; en-US; rv:1.7)
   Gecko/20040707 Firefox/0.8
Referer: http://www.example.com/foo/bar.php?abc=123&def=456
Cookie: uid=C50DF33E-E202-4206-B1F3-946AEDF9308B

HTTP/1.1 302 Moved Temporarily
Date: Wed, 28 Jul 2004 23:45:06 GMT
Location: http://static.example.net/i/foo/bar.gif
Content-Type: text/html

<a href="http://static.example.net/i/foo/bar.gif">Moved</a>
```


YAHOO!

Hit-metering for ads (3)

```
GET /i/foo/bar.gif HTTP/1.1
Host: static.example.net
User-Agent: Mozilla/5.0 (Windows; U; Windows NT 5.0; en-US; rv:1.7)
   Gecko/20040707 Firefox/0.8
Referer: http://www.example.com/foo/bar.php?abc=123&def=456

HTTP/1.1 200 OK
Date: Wed, 28 Jul 2004 23:45:07 GMT
Last-Modified: Mon, 05 Oct 1998 18:32:51 GMT
ETag: "69079e-ad91-40212cc8"
Cache-Control: public,max-age=315360000
Expires: Mon, 28 Jul 2014 23:45:07 GMT
Content-Length: 6096
Content-Type: image/gif

GIF89a...
```


YAHOO!

URL Tags & user experience

- Does not require modifying HTTP headers
  - No need for `Pragma: no-cache` or `Expires` in past
  - Doesn't break the Back button
- Browser history & visited-link highlighting
  - JavaScript timestamps/random numbers
    - Easy to implement
    - Breaks visited link highlighting
  - Session or Persistent ID preserves history
    - A little harder to implement

YAHOO!

Breaking the Back button

- User expectation: Back button works instantly
  - Private caches normally enable this behavior
- Aggressive cache-busting breaks Back button
  - Server sends `Pragma: no-cache` or `Expires` in past
  - Browser must re-visit server to re-fetch page
  - Hitting network much slower than hitting disk
  - User perceives lag
- Use aggressive approach very sparingly
  - Compromising user experience is A Bad Thing

YAHOO!

Summary

Review: Top 5 techniques

1. Use `Cache-Control: private` for personalized content
2. Implement “Images Never Expire” policy
3. Use a cookie-free TLD for static content
4. Use Apache defaults for occasionally-changing static content
5. Use random tags in URL for accurate hit metering or very sensitive content

YAHOO!

Pro-caching techniques

- **Cache-Control: max-age=**<bignum>
- **Expires:** <10 years into future>
- Generate "static content" headers
  - **Last-Modified, ETag**
  - **Content-Length**
- Avoid "cgi-bin", ".cgi" or "?" in URLs
  - Some proxies (e.g. Squid) won't cache
  - Workaround: use **PATH_INFO** instead

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YAHOO!

In other words, these are ways to make dynamic content look like static content.

Cache-busting techniques

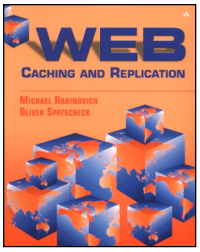
- Use POST instead of GET
- Use random strings and “?” char in URL
- Omit `Content-Length` & `Last-Modified`
- Send explicit headers on response
  - Breaks the back button
  - Only as a last resort

```
Cache-Control: max-age=0,no-cache,no-store
Expires: Tue, 11 Oct 1977 12:34:56 GMT
Pragma: no-cache
```


YAHOO!

Recommended Reading

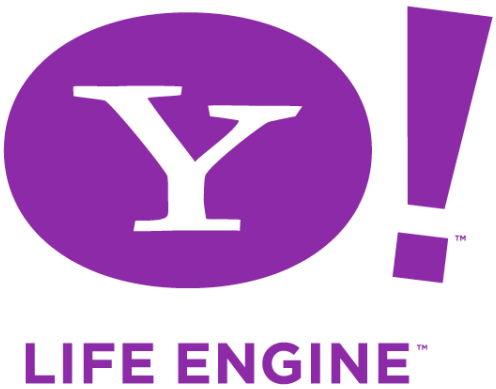
- Web Caching and Replication
  - Michael Rabinovich & Oliver Spatscheck
  - Addison-Wesley, 2001



- Web Caching
  - Duane Wessels
  - O'Reilly, 2001

YAHOO!

Slides: http://public.yahoo.com/~radwin/



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