



# COMPUTER NETWORKS

---

**Sivaraman Eswaran Ph.D.**

Department of Computer Science and Engineering

# COMPUTER NETWORKS

---

## Application Layer

**Sivaraman Eswaran Ph.D.**

Department of Computer Science and Engineering

## Unit – 2 Application Layer

2.1 Principles of Network Applications

**2.2 Web, HTTP and HTTPS**

2.3 The Domain Name System

2.4 P2P Applications

2.5 Socket Programming with TCP & UDP

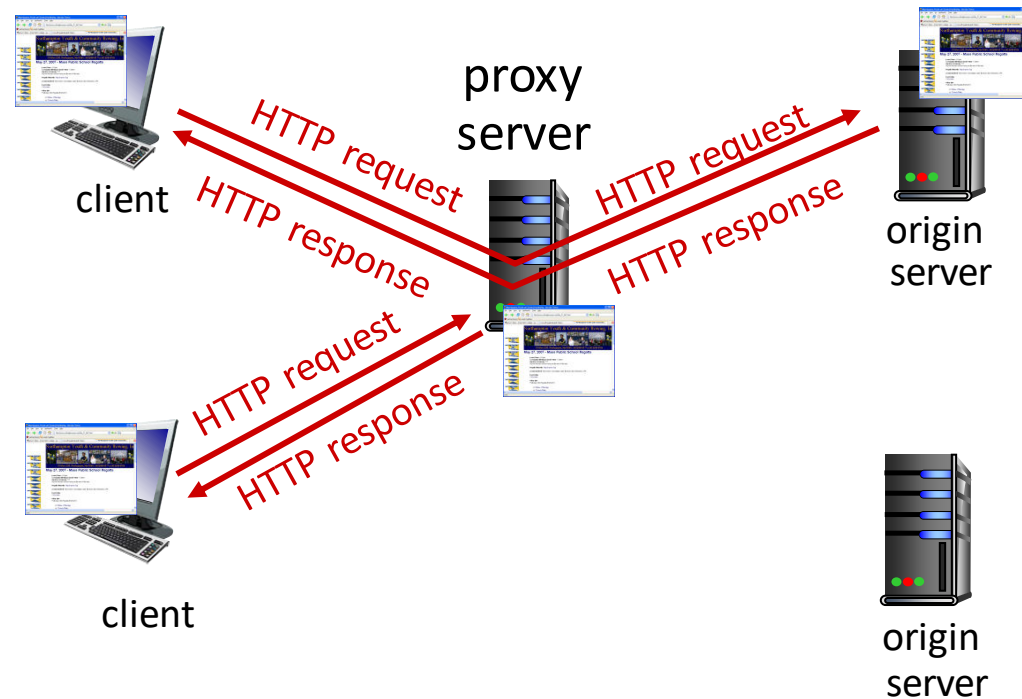
2.6 Other Application Layer Protocols

# COMPUTER NETWORKS

## Web Caches (Proxy Servers)

*Goal:* satisfy client request without involving origin server

- user configures browser to point to a *Web cache*
- browser sends all HTTP requests to cache
  - *if* object in cache: cache returns object to client
  - *else* cache requests object from origin server, caches received object, then returns object to client



- Web cache acts as both client and server
  - server for original requesting client
  - client to origin server
- typically cache is installed by ISP (university, company, residential ISP)

### *Why* Web caching?

- reduce response time for client request (speed)
  - cache is closer to client
- reduce traffic on an institution's access link (saves bandwidth)
- internet is dense with caches
  - enables “poor” content providers to more effectively deliver content
- privacy – surf the internet anonymously
- activity logging

# COMPUTER NETWORKS

## Caching example

$$(15 \text{ req/sec}) * (100 \text{ Kbits/req}) / (1.54 \text{ Mbps}) = 0.974$$

$$(15 \text{ req/sec}) * (100 \text{ Kbits/req}) / (1 \text{ Gbps}) = 0.0015$$

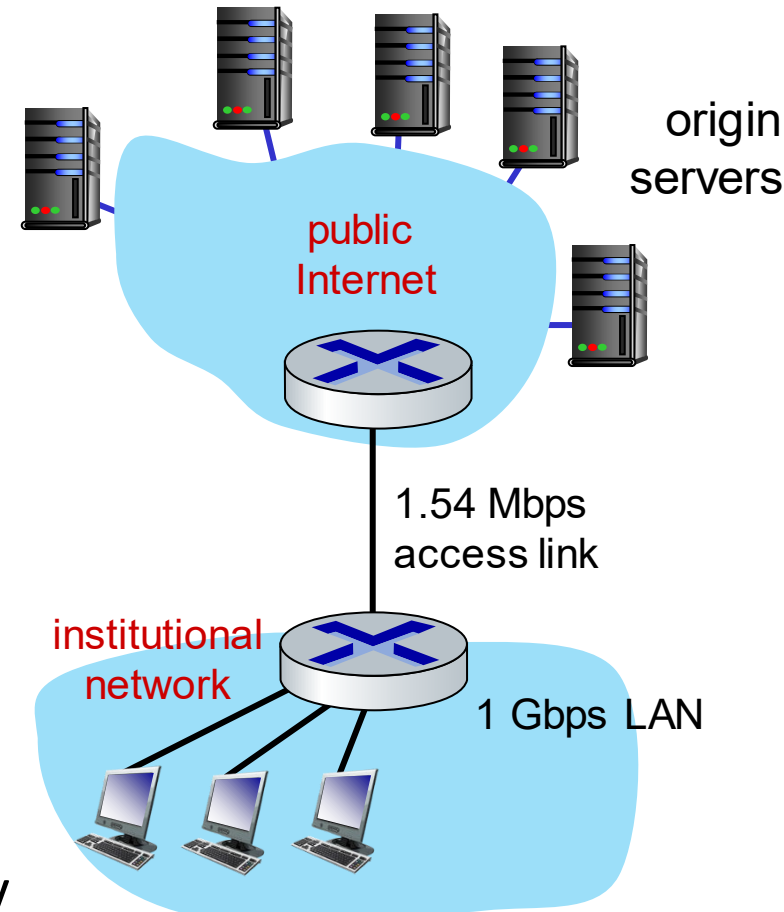
### Scenario:

- access link rate: 1.54 Mbps
- RTT from institutional router to server: 2 sec
- Web object size: 100K bits
- Average request rate from browsers to origin servers: 15/sec
  - average data rate to browsers: 1.50 Mbps

### Performance:

- LAN utilization: .0015
- access link utilization = .97
- end-end delay = Internet delay + access link delay + LAN delay  
= 2 sec + minutes + usecs

*problem: large delays at high utilization!*



# COMPUTER NETWORKS

## Caching example: buy a faster access link

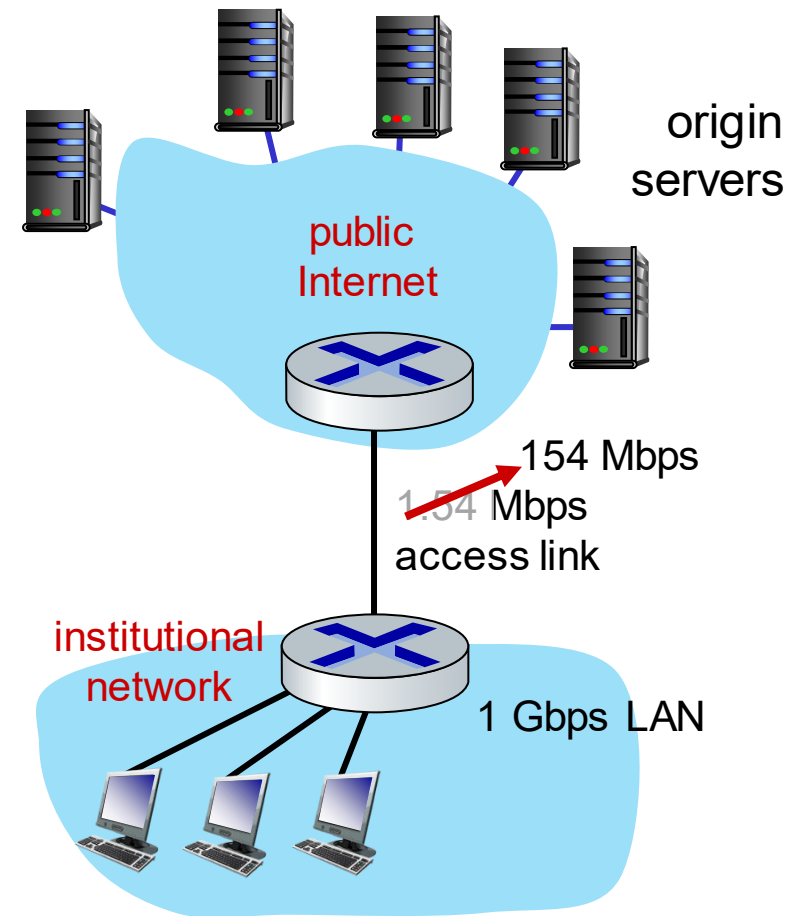
### Scenario:

- access link rate: ~~1.54~~ 154 Mbps
- RTT from institutional router to server: 2 sec
- Web object size: 100K bits
- Avg request rate from browsers to origin servers: 15/sec
  - avg data rate to browsers: 1.50 Mbps

### Performance:

- LAN utilization: .0015
- access link utilization = ~~.97~~ .0097
- end-end delay = Internet delay +  
access link delay + LAN delay  
= 2 sec + ~~minutes~~ + usecs

**Cost:** faster access link (expensive!) → msec



# COMPUTER NETWORKS

## Caching example: install a web cache

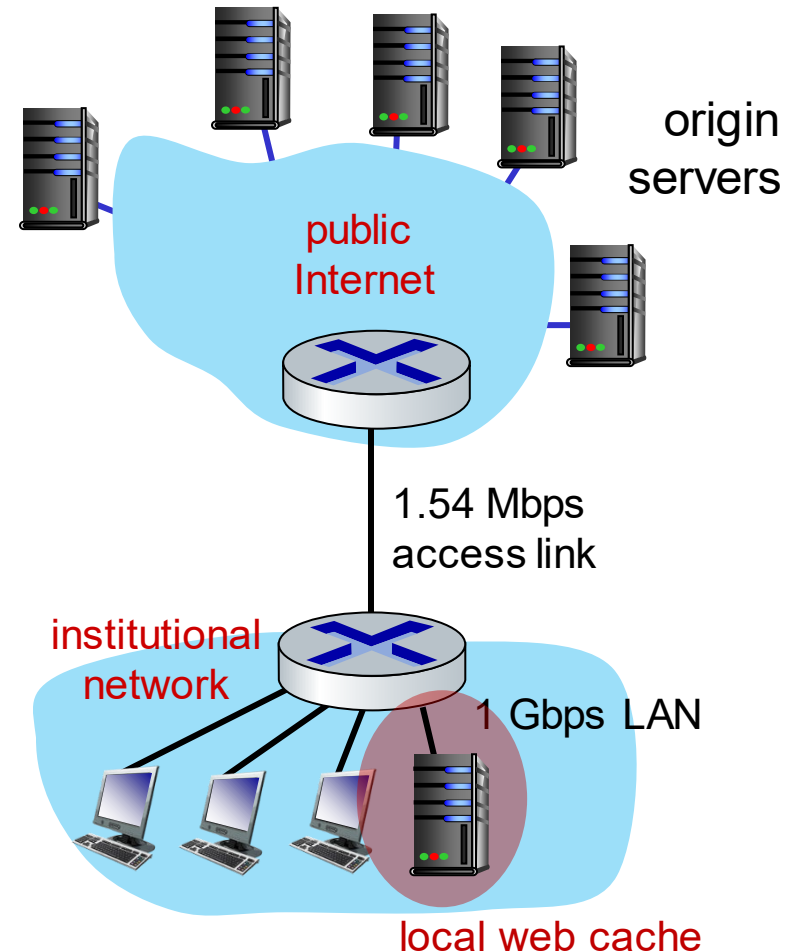
### Scenario:

- access link rate: 1.54 Mbps
- RTT from institutional router to server: 2 sec
- Web object size: 100K bits
- Avg request rate from browsers to origin servers: 15/sec
  - avg data rate to browsers: 1.50 Mbps

### Performance: *How to compute link utilization, delay?*

- LAN utilization: .?
- access link utilization = ?
- average end-end delay = ?

*Cost:* web cache (cheap!)



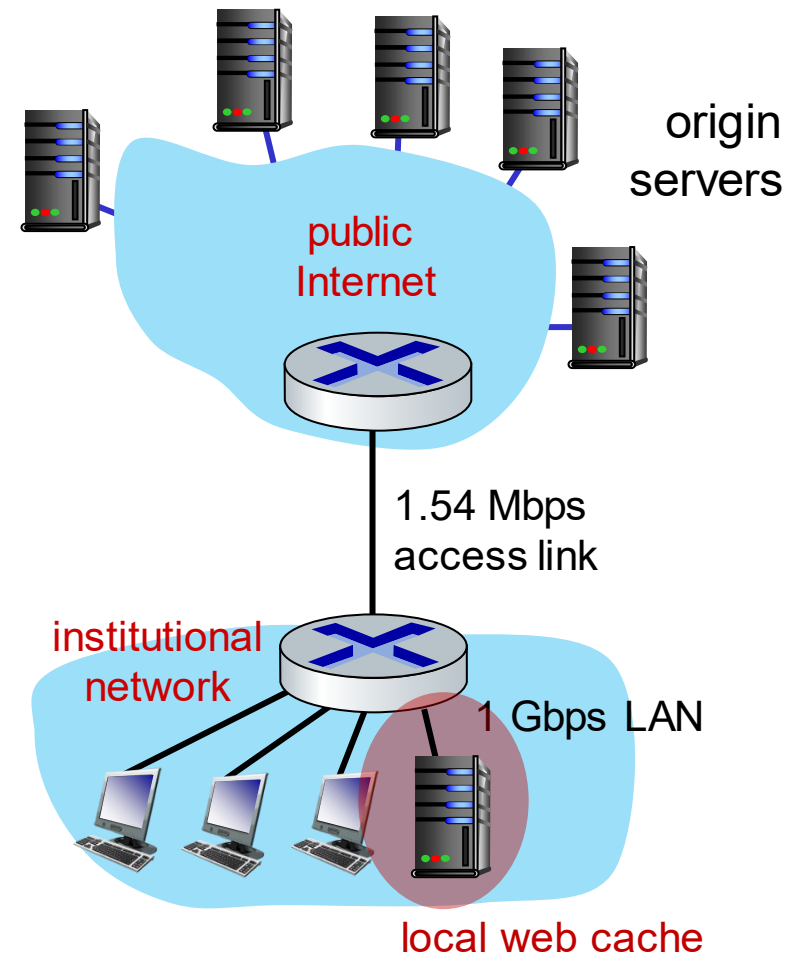


# COMPUTER NETWORKS

## Caching example: install a web cache

### Calculating access link utilization, end-end delay with cache:

- suppose cache hit rate is 0.4: 40% requests satisfied at cache, 60% requests satisfied at origin
- access link: 60% of requests use access link
- data rate to browsers over access link  
 $= 0.6 * 1.50 \text{ Mbps} = .9 \text{ Mbps}$
- utilization  $= 0.9 / 1.54 = .58$
- average end-end delay  
 $= 0.6 * (\text{delay from origin servers})$   
 $+ 0.4 * (\text{delay when satisfied at cache})$   
 $= 0.6 (2.01) + 0.4 (\sim \text{msecs}) = \sim 1.2 \text{ secs}$



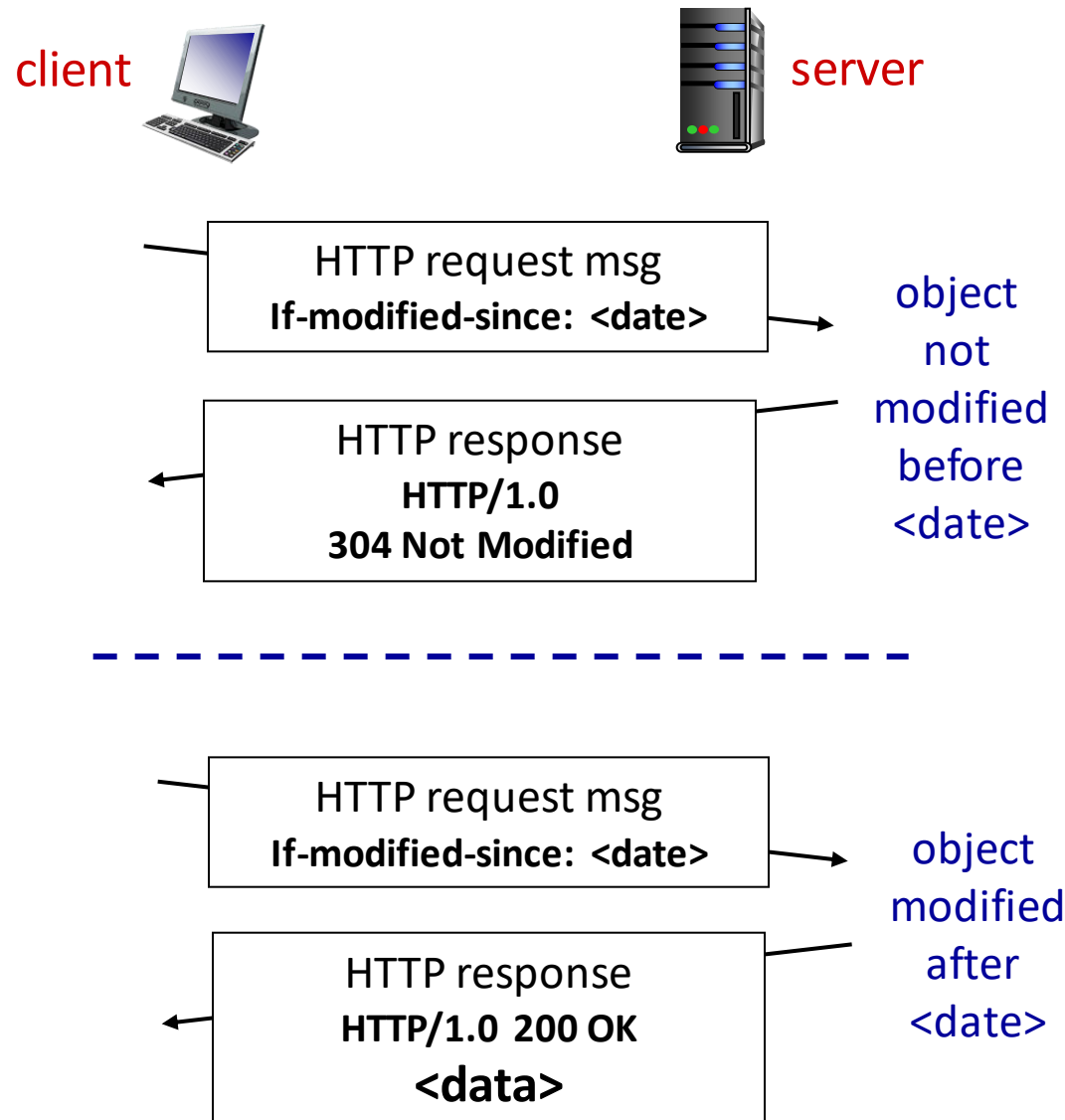
*lower average end-end delay than with 154 Mbps link (and cheaper too!)*

**Goal:** don't send object if cache has up-to-date cached version

- no object transmission delay
- lower link utilization

■ **cache:** specify date of cached copy in HTTP request  
**If-modified-since: <date>**

■ **server:** response contains no object if cached copy is up-to-date:  
**HTTP/1.0 304 Not Modified**



# COMPUTER NETWORKS

## Conditional Get (more)

Microsoft: \Device\NPF\_{483C83F4-DCBA-4863-B523-3C4E1B03D06F} [Wireshark 1.8.5 (SVN Rev 47350 from /trunk-1.8)]

File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help

Filter: http Expression... Clear Apply Save

No.	Time	Source	Destination	Protocol	Length	Info
4	20:33:03.198438000	10.36.40.181	149.152.32.102	HTTP	715	GET /ssp_director/p.php?a=UUFRRxiqyPSEqYHt1Pz04JzU6Iss7PT4uNio4MTI%2BNjkmky0gPScjKDonNz8x...
321	20:33:03.427289000	149.152.32.102	10.36.40.181	HTTP	1514	[TCP out-of-order] HTTP/1.1 200 OK (JPEG JFIF image)
340	20:33:09.383079000	10.36.40.181	128.119.245.12	HTTP	473	GET /wireshark-labs/HTTP-wireshark-file2.html HTTP/1.1
341	20:33:09.407557000	128.119.245.12	10.36.40.181	HTTP	701	HTTP/1.1 200 OK (text/html)
343	20:33:09.677244000	10.36.40.181	128.119.245.12	HTTP	384	GET /favicon.ico HTTP/1.1
344	20:33:09.689986000	128.119.245.12	10.36.40.181	HTTP	532	HTTP/1.1 404 Not Found (text/html)
347	20:33:14.318343000	10.36.40.181	128.119.245.12	HTTP	586	GET /wireshark-labs/HTTP-wireshark-file2.html HTTP/1.1
348	20:33:14.331881000	128.119.245.12	10.36.40.181	HTTP	319	HTTP/1.1 304 Not Modified
349	20:33:14.410192000	10.36.40.181	128.119.245.12	HTTP	384	GET /favicon.ico HTTP/1.1
350	20:33:14.426443000	128.119.245.12	10.36.40.181	HTTP	532	HTTP/1.1 404 Not Found (text/html)

Ethernet II, Src: HonHaiPr\_0a:de:6b (cc:af:78:0a:de:6b), Dst: Cisco\_4c:61:3f (00:1e:f7:4c:61:3f)

Internet Protocol Version 4, Src: 10.36.40.181 (10.36.40.181), Dst: 128.119.245.12 (128.119.245.12)

Transmission Control Protocol, Src Port: 55404 (55404), Dst Port: http (80), Seq: 750, Ack: 1126, Len: 532

Hypertext Transfer Protocol

GET /wireshark-labs/HTTP-wireshark-file2.html HTTP/1.1\r\n

Host: gaia.cs.umass.edu\r\n

Connection: keep-alive\r\n

Cache-Control: max-age=0\r\n

Accept: text/html,application/xhtml+xml,application/xml;q=0.9,\*/\*;q=0.8\r\n

User-Agent: Mozilla/5.0 (windows NT 6.1; WOW64) AppleWebKit/537.22 (KHTML, like Gecko) Chrome/25.0.1364.97 Safari/537.22\r\n

Accept-Encoding: gzip,deflate,sdch\r\n

Accept-Language: en-US,en;q=0.8\r\n

Accept-Charset: ISO-8859-1,utf-8;q=0.7,\*;q=0.3\r\n

If-Modified-Since: wed, 27 Feb 2013 01:33:01 GMT\r\n

[Full request URI: http://gaia.cs.umass.edu/wireshark-labs/HTTP-wireshark-file2.html]

01d0 20 49 53 4f 2d 38 35 39 2d 31 2c 75 74 66 2d ISO-8859-1,utf-8;q=0.7,\*;q=0.3.  
01e0 38 3b 71 3d 30 2e 37 2c 2a 3b 71 3d 30 2e 33 0d .If-None-Match:  
01f0 0a 49 66 2d 4e 6f 6e 65 2d 4d 61 74 63 68 3a 20 "d6c96-1 73-c1336  
0200 22 64 36 63 39 2d 31 37 33 2d 63 31 33 33 36 d40".If-Modified  
0210 64 34 30 22 0d 0a 49 66 2d 4d 6f 64 69 66 69 65 Since: wed, 27  
0220 64 2d 53 69 6e 63 65 3a 20 57 65 64 2c 20 32 37 Feb 2013 01:33:  
0230 20 46 65 62 20 32 30 31 33 20 30 31 3a 33 33 3a 01 GMT..  
0240 30 31 20 47 4d 54 0d 0a 0d 0a ..

Text item (text), 50 bytes

Packets: 367 Displayed: 10 Marked: 0 Dropped: 0

Profile: Default



**THANK YOU**

---

**Sivaraman Eswaran Ph.D.**

Department of Computer Science and Engineering

**[sivaramane@pes.edu](mailto:sivaramane@pes.edu)**

**+91 80 6666 3333 Extn 834**