Internet and Intranet Protocols and Applications

Lecture 8b: Proxy Server Load Balancing

March, 2004

Arthur Goldberg
Computer Science Department
New York University
artg@cs.nyu.edu

Load Balancing

- Problem: Single physical Origin or Proxy Server may not be able to handle its load
- Solution: install multiple servers and distribute the requests.
- How do we distribute requests among the servers?

DNS Round Robin

- DNS is configured so multiple IP Addresses correspond to a single host name
  - multiple type “A” records in DNS Database

```
A   harpo       10.0.0.15
A   harpo       10.0.0.16
A   harpo       10.0.0.17
```

- Modify the DNS server to round-robin through through the IP addresses for each new request
- This way, different clients are pointed to different servers

Problems with DNS Round Robin

- Not optimal for proxy servers
  - cache content is duplicated (why?)
  - multi-tier proxy arrangement won't work if cookies are used
  - load is not truly balanced
    - assignment is at DNS lookup level, *not* HTTP request level
- Failures are seen by the client (why?)

ICP
Internet Cache Protocol

- Used for querying proxy servers for cached documents
- Typically used by proxy servers to check other proxy server’s cache
- Could be used by clients however
- RFC 2186, 2187

ICP

- ICP request has desired URL in it
- send via UDP to other proxy servers
- Other proxy servers respond “HIT” or “MISS”
- Works better in LANs than Internet (why?)
- Might IP multicast help?

Problems with ICP

- ICP queries generate extra network traffic
- Does not scale well
  - more proxy servers = more querying
- Caches become redundant

Non-redundant Proxy Load Balancing

- Proxy selection based on a hash function
- Hash value is calculated from the URL
- Use resulting hash value to choose proxy
- Use Host name in hash function to ensure request routed to same proxy server (why?)

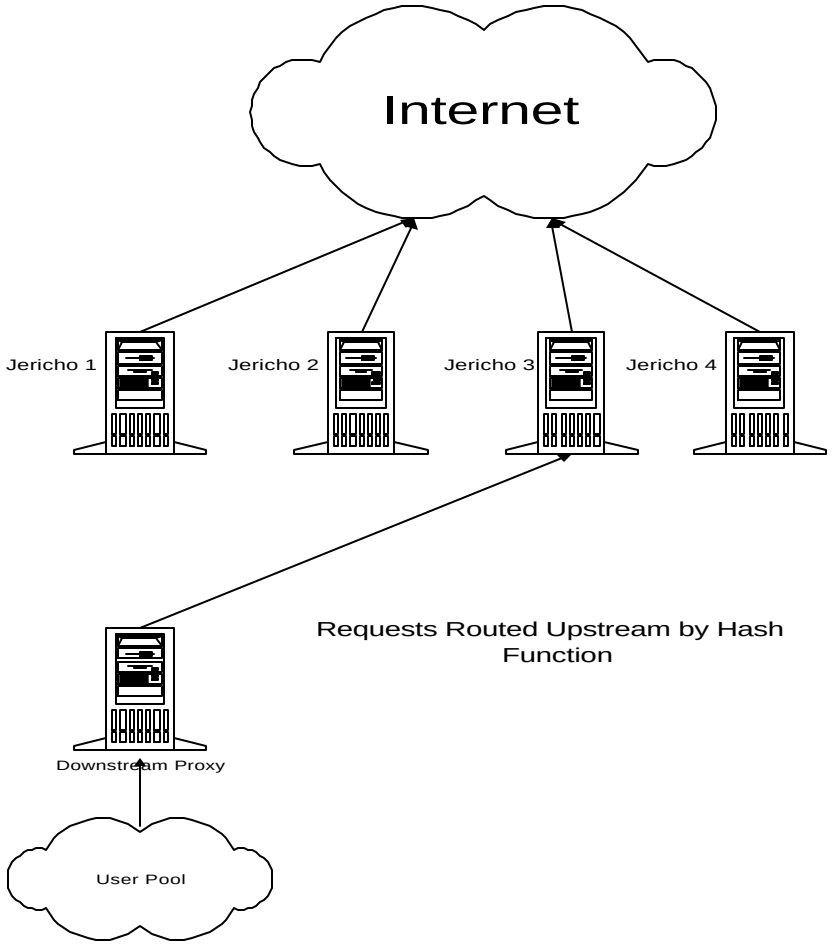
Cache Array Routing Protocol (CARP)

- Hash-based proxy selection mechanism
- No queries
  - hashing used to select server
- Highly scalable
  - performance improves as size of array increases
  - automatically adjusts to additions/deletions of servers
- Eliminates cache redundancy
- No new protocols!

How CARP Works

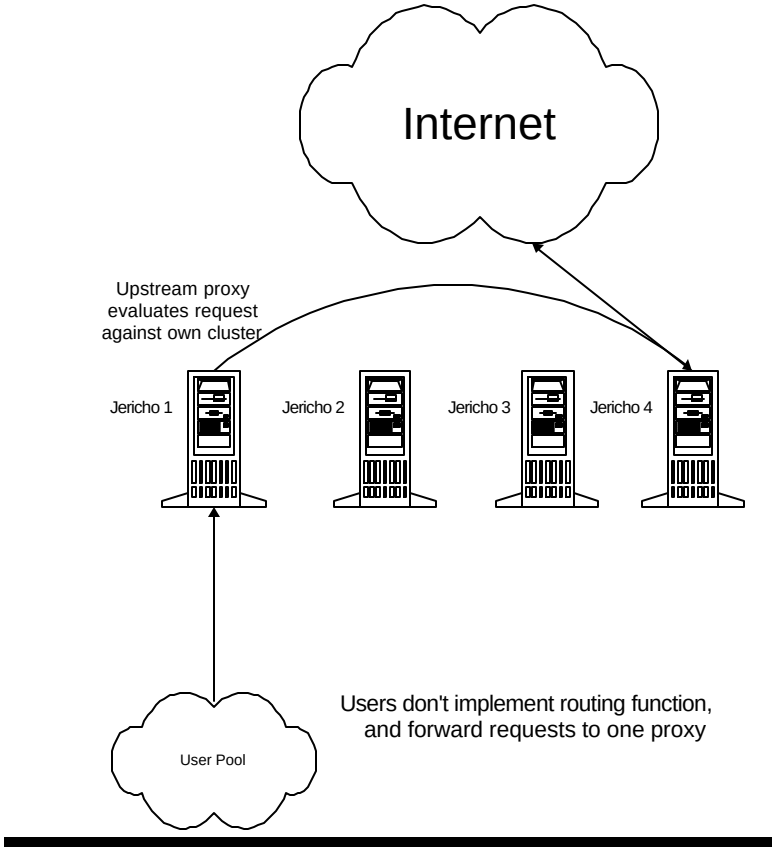
- Given an array of Proxy servers
- Assume array membership is tracked using a membership list
- A hash value $\boldsymbol{H_s}$ is computed for the name of each proxy server in list (only when list changes)
- A hash value $\boldsymbol{H_u}$ is computed for the name of each requested URL
- For each request, a combined hash value $\boldsymbol{H_c}$ = F($\boldsymbol{H_s}$, $\boldsymbol{H_u}$) is computed for all servers
- Use highest $\boldsymbol{H_c}$ to select server

CARP: Hierarchical Routing



- One server acts as director using Hash routing.
- Cache hit rate is maximized (why?)
- Single point of failure (use DNS RR?)

CARP: Distributed Routing



- Requests can be sent directly to ANY member of the Array.
- Route request to best score if not me.
- Don’t cache response if redirected

CARP Features

- Assume the membership stays the same
- Then a given URL always maps to the same Proxy (because the hash functions are deterministic)
  - Thus, a given page always resides in the same proxy
  - So caching works
  - And pages are not stored redundantly
- When a membership of size n changes by one, only 1/n th of the URLs are remapped

CARP Example

		www.microsoft.com	www.yahoo.com	www.msn.com	www.ibm.com
Proxy	Hash	19	14	5	2
Jericho1	13	5	6	10	4
Jericho2	8	9	2	7	5
Jericho3	5	7	4	3	10
Jericho4	28	4	7	8	1

Note the distribution of URL across servers

CARP: adding a new server

		www.microsoft.com	www.yahoo.com	www.msn.com	www.ibm.com
Proxy	Hash	19	14	5	2
Jericho1	13	5	6	10	4
Jericho2	8	9	2	7	5
Jericho3	5	7	4	3	10
Jericho4	28	4	7	8	1
Jericho5	14	2	9	4	6

A 5th server is added and effects only 1/5 of the existing mappings

The CARP Hash Functions

- Host (server) Hash
  - Computations use 32 bit UNSIGNED integers

```
H_S = 0;  // initially
for each character C_i in host name
    H_S += R(H_S, 19) + C_i
    // where R(x,n) ::= logical left rotate x by n
End for
H_S += H_S*0x62531965
H_S = R(H_S , 21)
```

The CARP Hash Functions

- URL Hash
  - Computations use 32 bit UNSIGNED integers

```
H_U = 0;  // initial H_U = 0;
for each character C_i  in URL
   H_U += R(H_U, 19) + C_i
End for
```

The CARP Hash Functions

- Combining Hash Function
  - Again, all computations are performed using 32-bit unsigned integers

```
Hc = Hu ^ Hs   // [exclusive OR]
Hc += Hc*0x62531965
Hc = R(Hc , 21)
```

The CARP Membership Table

The format of the table is:

This information is the **Global Information** given once per table

Proxy Array Information/<Version number>
ArrayEnabled: <0 | 1>
ConfigID: <opaque string>
ArrayName: <opaque string>

ListTTL: <minutes until next check>

<CR>LF>

The following fields are given for **EACH member** of the Array

<name> <IP addr> <listening port> <table URL> <agent str>
<statetime> <status UP | DOWN> <load factor> <cache size>

CARP Membership Table
Global Information

- Applies to the entire Array
- The **ListTTL** is most important field. It gives time in seconds that this copy of table is valid. After this time, a new copy of the table must be obtained.
- Global fields are separated by <CR><LF>
- Global Information is separated from member information by blank line (<CR><LF>)

CARP Membership Entries

- Fields in the membership record for a member are separated by spaces
- Member records are separated by <CR><LF>
- Important fields are:
  - ***Name:*** the host name of this proxy server
  - ***IP Addr:*** IP address for server (if not present, resolve host name)
  - ***Listening Port:*** TCP port this proxy is listening on

CARP Membership Entries

- Table URL
  - URL for membership table
- Agent String (informational)
- Statetime
  - how long this member has been in array and current state
- Status (UP | Down)
  - member accept requests, or refused connection on last request
- Load Factor
  - relative amount of total load that server can handle
- Cache Size (informational)