Cache Array Routing Protocol v1.1

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Abstract

This draft documents proposed changes to the original version of the draft with this same name, to be called ‘the Cache Array Routing Protocol (CARP) v1.1’ for dividing URL-space among an array of loosely coupled proxy servers.

The modified sections are 3.1 and 3.2. Aside from those two sections, the drafts remains the same.

An overview of the changes are presented in section 0.

An HTTP client agent (either a proxy server or a client browser) which implements CARP v1.1 can allocate and intelligently route requests for the correct URLs to any member of the Proxy Array. Due to the resulting sorting of requests through these proxies, duplication of cache contents is eliminated and global cache hit rates are improved.
0. Proposed Change Overview

Change in hash functions
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The following changes are to make hash functions faster, better
(resulting in more uniform distribution), and easier to evaluate
(epecially in JavaScript on client side).

1. Convert a URL to lower case to evaluate hash value to avoid parsing
   the URL. This makes hashing faster at client as well as server side.

2. Use shift instead of rotate operator. It is four times faster and
gives more uniform distribution based on our experiments.

3. Additive multiplication is replaced with a simple multiplication.
   Additive effect can be achieved simply by adding 1 to the multiplier
   constant if required. Since the multiplier constant is anyway a set of
   random bits, adding 1 to it has no effect toward improving distribution.

4. The second rotate operation in evaluation of member proxy hash
   values as well as resultant hash value is eliminated. It is a relatively
   expensive operation and does not help improve distribution after the
   multiplication.

1. Overview

The Cache Array Routing Protocol describes a distributed caching
protocol based on

1) a known membership list of loosely coupled proxies and
2) a hash function for dividing URL space among those proxies

The Proxy Array Membership Table is defined as a plain ASCII text
file retrieved from an Array Configuration URL. This document does
NOT describe how this table is constructed, merely the format of
the fields used by agents implementing.

The hash function plus routing algorithm defined in this document
take member proxies described in the Proxy Array Membership Table
and make an on-the-fly determination as to which Proxy Array member
should be the proper receptacle for a cached version of a resource
keyed by URL.

Downstream agents may then access the cached resource by forwarding
the proxied HTTP request [5] for that resource to the appropriate
member of the Proxy Array.
2. Proxy Array Membership Table

The Proxy Array Membership Table is a plain-text ASCII file which can be published from a URL.

The format of the table is:

Proxy Array Information/<Version number>
ArrayEnabled: <0 | 1>
ConfigID: <opaque string>
ArrayName: <opaque string>
ListTTL: <minutes until next check>

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

2.1 Global Information

These are fields that describe the array itself and are not specific to any one member of an array

Global information is terminated in the Proxy Array Membership Table by a CR/LF/CR/LF.

2.1.1 Version number

The version number for implementations of this specification is 1.0

2.1.2 ArrayEnabled

This field allows proxies to advertise their implementation of CARP v1 even if they are not members of a Proxy Array.

2.1.3 ConfigID

ConfigID is an opaque number no larger than 32bits similar to an ETag in HTTP 1.1. It is used to track the current state of an Array table and may be used to match multiple yet independently published copies of the Proxy Array Membership Table.

2.1.4 ArrayName

ArrayName is an opaque string which is used to provide a convenient administrative name for a given array.

2.1.5 ListTTL

ListTTL is the number of seconds for which an HTTP client entity should consider the current table image valid. After ListTTL has expired, that client should retrieve a new copy of the Proxy Array Membership Table.
2.2 Member Information

The following fields are published per member in an array and are separated by single spaces. The end of an array member’s record is terminated by a CR/LF.

2.2.1 Name

The name of the proxy server. Typically this is the fully qualified DNS name. Downstream HTTP agents should use resolution of this name to determine how to connect to this proxy.

2.2.2 IP Addr

The IP address that other proxy servers within this array should use to connect to this proxy server. This is necessary for proxy servers which may be hosted on multi-homed servers where requests are only accepted by one of the interfaces.

2.2.3 Listening Port

The TCP port number this proxy is expecting requests on.

2.2.4 Table URL

A URL which may be maintained by this proxy server on which a copy of the array membership table can be found.

2.2.5 Agent String

An opaque string identifying the vendor / version of the proxy Server in the Array Membership Table.

2.2.7 Statetime

How long a Proxy Server has been in its current state and has been a member of this table. This is useful for dynamic generation of the Array Membership Table where the host generating the table has knowledge of the proxy’s operational status.

2.2.8 Status

Status provides a simple text string indicating whether a member proxy is currently able to handle requests (UP) or refused a connection when last contacted (DOWN).
2.2.9 Load Factor

Load Factor is a relative amount of the total load for an array that should be handled by any given member of the array.

2.2.10 Cache Size

Cache size is an informational field that indicates the size of the cache held by a particular member of an array.

3. Routing Function

Once an agent has a Proxy Array Membership Table. It uses a mathematical hash function to determine which of the members of the array should be the receptacle of a particular URL request.

This routing function involves constructing n "scores" using a hash of the request URL plus a hash of each of the n proxies in the Proxy Array Membership Table.

Both the URL and the proxy names are hashed in order to minimize the disruption of target routes if a member of the target array can’t be contacted.

Hashes of the URL and proxy name are constructed using the algorithm described in 3.1 and combined using the algorithm described in 3.2.

3.1. Hash Function

The hash function outputs a 32 bit unsigned integers based on a zero-terminated ASCII input string. Machine names as well as URLs should be converted to lower case for hash evaluation. This makes sense because machine names are case insensitive.

Because irreversibility and strong cryptographic features are unnecessary for this application, a very simple and fast hash function based on the bitwise left shift operator is used.

For (each char in URL):
   URL_Hash += (URL_Hash << 9) + char ;

Member proxy hashes are computed in a similar manner:

For (each char in MemberProxyName):
   MemberProxy_Hash += (MemberProxy_Hash << 9) + char ;

Because member names are often similar to each other, their hash values are further spread across hash space via a multiplication:

MemberProxy_Hash = MemberProxy_Hash * 0x62531965 ;
3.2. Hash Combination

Hashes are combined by first exclusive or-ing (XOR) the URL hash by the machine name and then multiplying by a constant.

All final and intermediate values are 32 bit unsigned integers.

Combined_Hash = (URL_hash ^ MemberProxy_Hash) ;
Combined_Hash = Combined_Hash * 0x62531965 ;

3.3. Load Factor

Support for array members with differing HTTP processing & caching capacity is achieved by multiplying each of the combined hash values by a Load Factor Multiplier.

The Load Factor Multiplier for an individual member is calculated by taking each member’s relative Load Factor and applying the following formula:

For each proxy server 1,...,K, the Load Factor Multiplier, X_k, is calculated iteratively as follows:

X_1 = arbitrary positive constant

X_k = ([K-k+1] * [P_k - P_{k-1}])/(X_1 * X_2 * ... * X_{k-1})
X_k += (X_{k-1}^{K-k+1})
X_k = X_k^{1/(K-k+1)}

where:

X_k = Load Factor Multiplier for proxy k
K = number of proxies in an array
P_k = relative percent of the load that proxy k should handle

This is then combined with the previously computed hashes as

Resultant_value = Combined_Hash * X_k
3.4. Route Selection

The "score" for a particular combination of URL plus proxy is its resultant value. Once the agent determines of the scores of the K proxies, it routes the URL query to the proxy with the highest score.

3.5. Member Failure Routing

If a proxy cannot contact the designated member of a proxy array in order to forward an HTTP request, that proxy should route the request to the second highest scoring proxy in the target array.

4. Client-side implementation

CARP can be implemented on client-side HTTP browsers via the use of the Proxy AutoConfig file described in [1] and [2].

5. Versioning

If a downstream proxy receives an Array Membership Table with a greater version # than that proxy is able to parse, it should fall back to simple proxy request routing to any administrator defined upstream proxy server.

6. Security Considerations

This draft does not discuss relevant security considerations.

7. Open Issues

8. Acknowledgements

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9. References


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