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Implementing Distributed Server Groups for the World Wide Web

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Abstract

The World Wide Web (WWW) has recently become a very popular facility for the dissemination of information. As a result of this popularity, it is experiencing rapidly increasing traffic load. Single machine servers cannot keep pace with the ever greater load being placed upon them. To alleviate this problem, we have implemented a distributed Web server group. The server group can effectively balance request load amongst its members (within about 10% of optimal), and client response time is no worse than in the single server case. Client response time was not improved because the measured client traffic consumed all available network throughput. The distributed operation of the server groups is completely transparent to standard Web clients.

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1. Introduction

As the exponential growth of the World Wide Web continues with no near-term end in sight, the load placed on popular Web servers is often too great for a single server machine to handle. When the volume of requests to a server becomes prohibitively high the server tends to drop requests and eventually crashes. The service provider needs more computing power to meet the demands of the clients requesting the service. One solution is to simply buy a bigger machine that can handle the large load of service requests. This solution is, however, unacceptable; it provides only temporary relief from server overload. If server usage continues to grow rapidly, even the more powerful server will eventually be overwhelmed. This problem is likely to become more significant over the next few years as the number of commercial service providers and the size of the data objects being exchanged are likely to increase dramatically.

A fairly obvious solution to this problem is to implement a distributed Web server which will spread incoming request load among several machines. There is, however, a significant problem with this approach. The HyperText Transfer Protocol (HTTP/1.0) used by Web clients and servers identifies a resource on the Web using a valid hostname. Consequently, a distributed server needs to present a single hostname to maintain compatibility with existing Web clients. We can alleviate this problem by extending the concept of distributed process groups to the Web server level. A distributed server group exports a single logical name and address to the outside world. From the viewpoint of a client sending an HTTP request, the server group is a single server that will handle the HTTP request in the same way that any other Web server would. Once the server group receives a request it transparently allocates it to an appropriate member of the group for processing.

By supporting distributed Web server groups, we can provide a mechanism for smoothly scaling the server capacity of Web service providers. The use of server groups can reduce the latency of servicing a request provided there is sufficient available network bandwidth to accommodate higher request throughput. Our Web server group implementation can effectively balance request load, and is transparent to Web clients which support the HTTP/1.0 protocol.

2. The World Wide Web

2.1. The HTTP Protocol

The fundamental mechanism underlying the Web is the HTTP protocol. The protocol is stateless, object-oriented, and textual. A complete description of the current protocol can be found on-line at [CERN]. For our purposes, we are only interested in the basic structure of the protocol.

HTTP is an RPC-like protocol; clients make requests of servers and receive responses. The general format of a request is:

method	URL	protocol version	CrLf	GET /doc.html HTTP/1.0 <CrLf>
optional header information			CrLf	<CrLf>
Body				<end>

Figure 1: HTTP request format.

Figure 2: Example HTTP request.

This figure needs some explanation. A *URL* is simply a name for an object; typically, the hierarchical naming scheme of the Unix file system is used. The *method* given in the request is a method to be invoked on the object named by the given URL. The **CrLf** tag represent the pair of characters carriage return and line feed. The *optional header information* is a series of MIME headers which can be used to specify a variety of things including client name, user name,

encoding type, date, authorization information, etc. The *body* of the request is interpreted by the method which is invoked; it is in essence the argument list for the method.

Once the server receives a request from a client, it processes the request and returns a response. A reply from the server has the following structure:

protocol version	status code	reason	CrLf	HTTP/1.0 200 OK <CrLf>
optional header information			CrLf	Server: NCSA/1.3 Content-type: text/html <CrLf>
Body				HTML document <end>

Figure 3: HTTP response format.

Figure 4: Example HTTP response.

The *status code* indicates the result of the request; the *reason* field provides a human-readable textual explanation of the status code. The rest of the fields of the response fulfill similar roles to their counterparts in the request.

In current patterns of Web use, the GET method is by far the most frequently used. In fact, Web sessions typically consist exclusively of GETs. This reflects the fact that the Web is currently used primarily as a means of fetching files, albeit in many formats, including hypertext.

2.2. Web Servers and Clients

Servers and clients use the HTTP protocol described above to exchange information. The general model of the Web currently in use is this: servers export a hierarchical file space to clients. This file space is populated by “documents” of various types. The primary function of Web clients is to acquire documents from this file space in response to user actions. The client and server must also negotiate a document format which is acceptable to them both. Web servers and clients communicate with each other over TCP/IP streams. The general model of an HTTP transaction is:

- The client opens a TCP/IP connection to the server,
- The client sends its request over this stream,
- The server sends its response back,
- And the connection is closed.

In the case of the most widely used Web server (NCSA’s `httpd`), the server forks a new process for each connection. That process receives the request from the client, processes it, sends back a response, and exits.

3. A Distributed Web Server Group

Since its inception, the Web has experienced very rapid growth in usage and amount of data being provided. The growth of the user community has generated increasing demand for data, and the raw amount of data has also increased due to the proliferation of large multimedia resources. The result has been continually increasing stress on Web servers.

A natural solution is to group several server machines into a single server group. The server group would provide a single logical service but would physically share incoming requests amongst its member machines. The need for this is indeed real; NCSA has implemented a similar scheme for their server after a single server machine was no longer able to cope with the heavy load [KBM94].

In order for a Web server group to be useful it must operate transparently within the existing Web. In other words, it

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