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(54) SYSTEM AND METHOD FOR REFORMATTING DATA TRAFFIC

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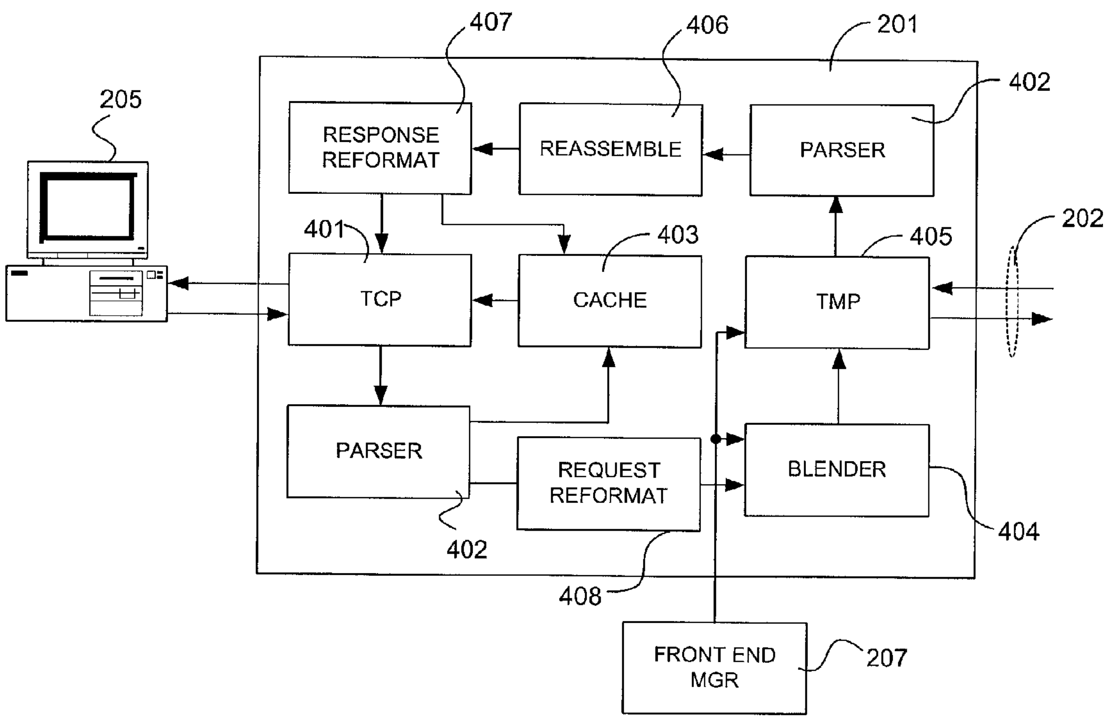
(57) **ABSTRACT**

A method for delivering network resources involving establishing data traffic between a two or more network-connected computers. Data contained within the traffic is reformatted at least once in an intermediary computer between the first and second computers.



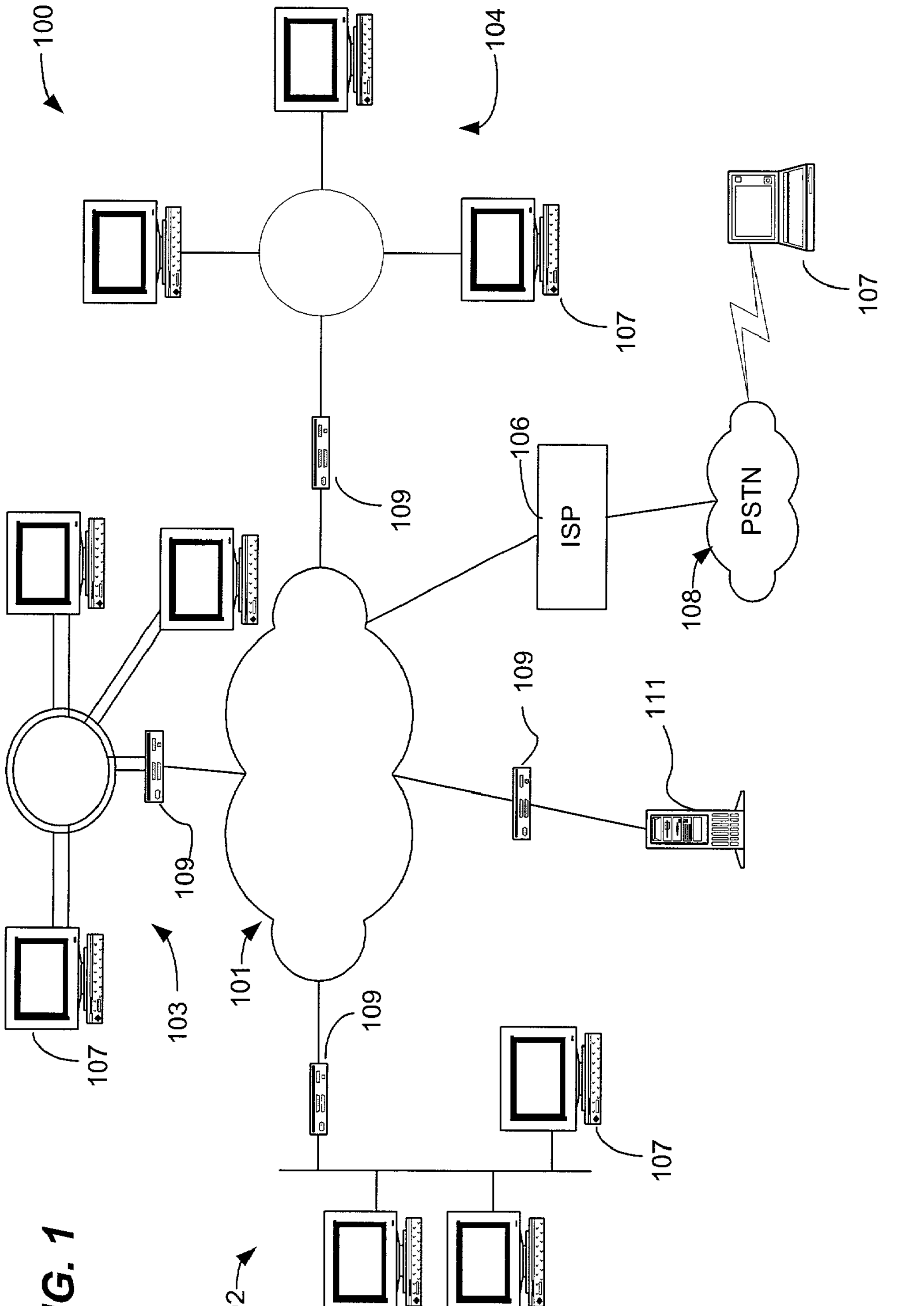

100
104
107
107
107
107
107
109
109
109
109
106
ISP
PSTN
108
111
101
103
102

FIG. 1

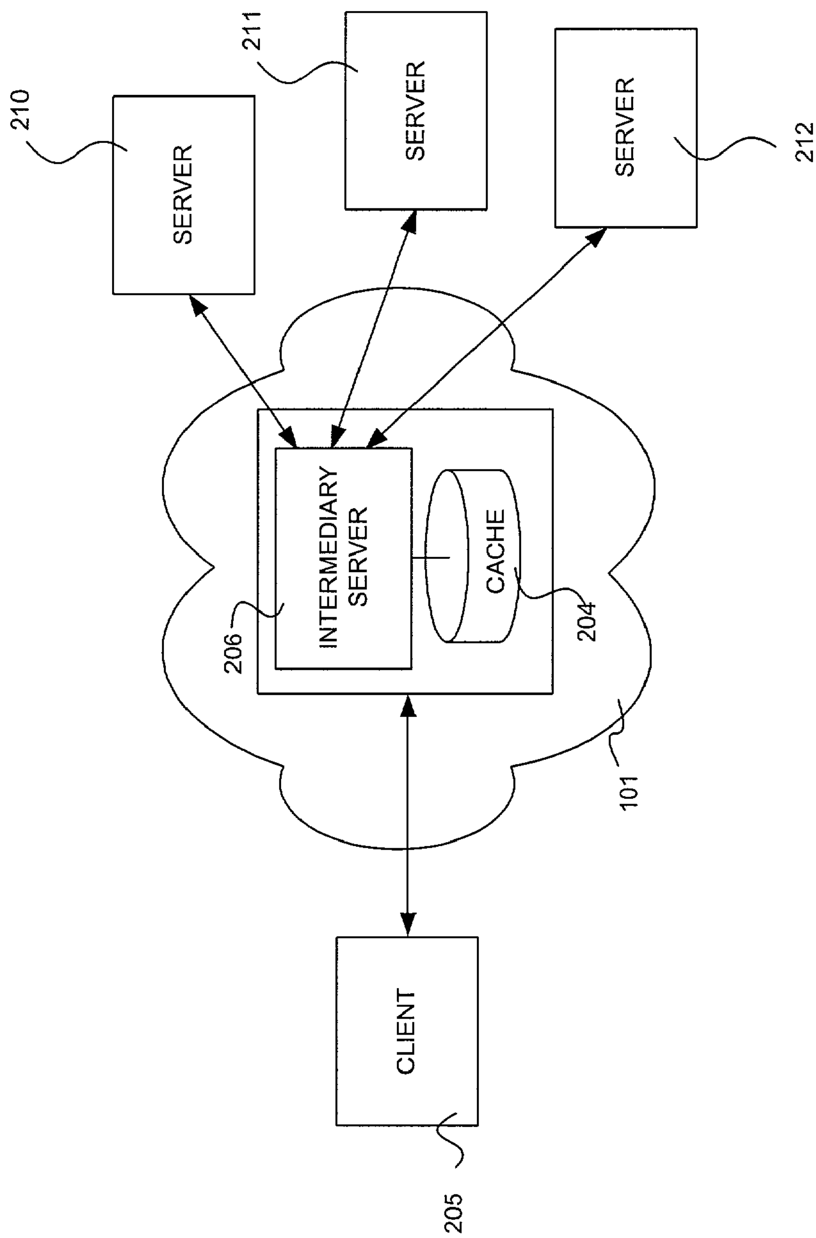

210
SERVER
211
SERVER
SERVER
212
INTERMEDIARY SERVER
CACHE
206
204
101
CLIENT
205

FIG. 2A

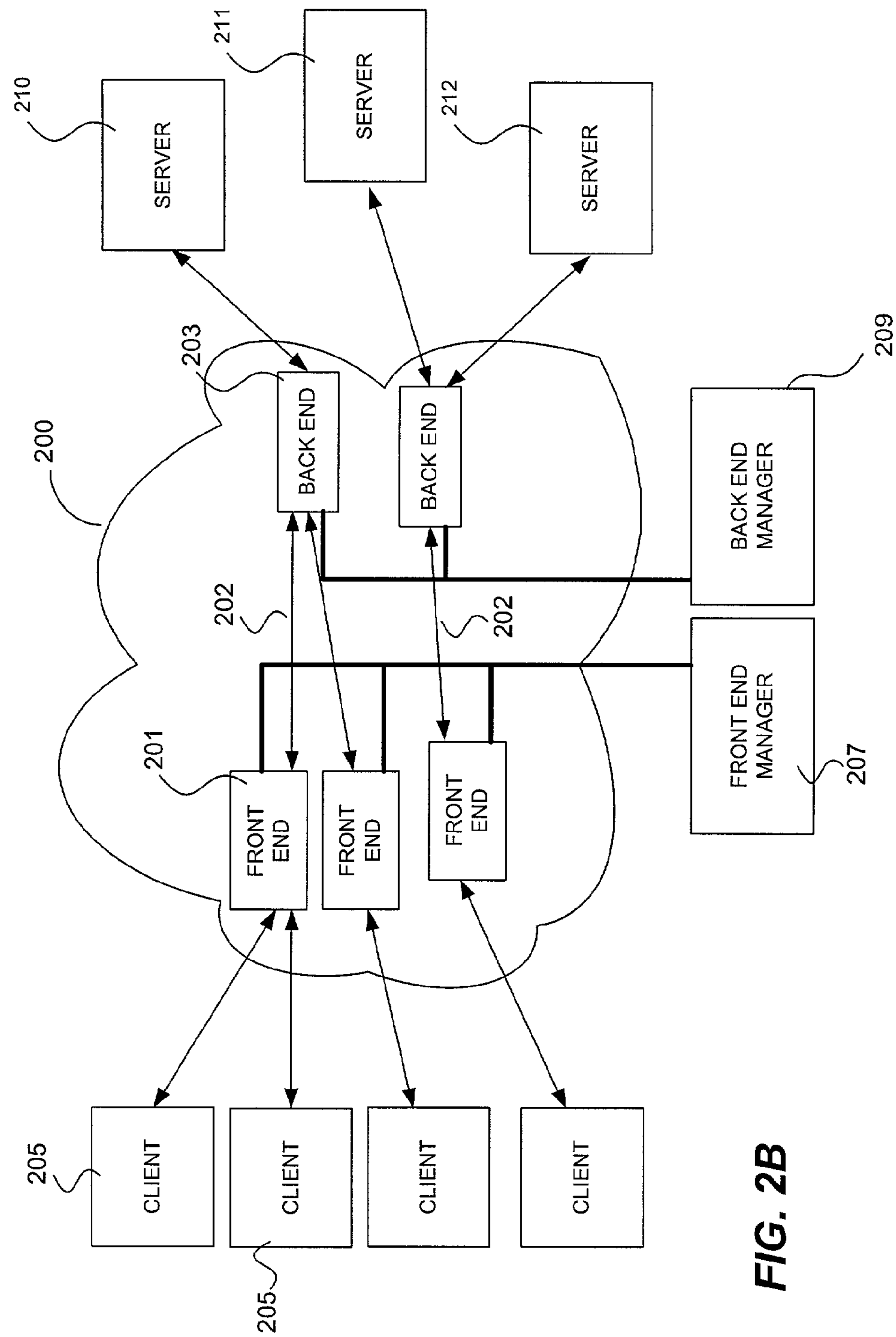

210
SERVER
211
SERVER
212
SERVER
200
203
BACK END
BACK END
209
BACK END MANAGER
202
202
201
FRONT END
FRONT END
FRONT END
FRONT END MANAGER
207
205
CLIENT
CLIENT
CLIENT
CLIENT
205

FIG. 2B

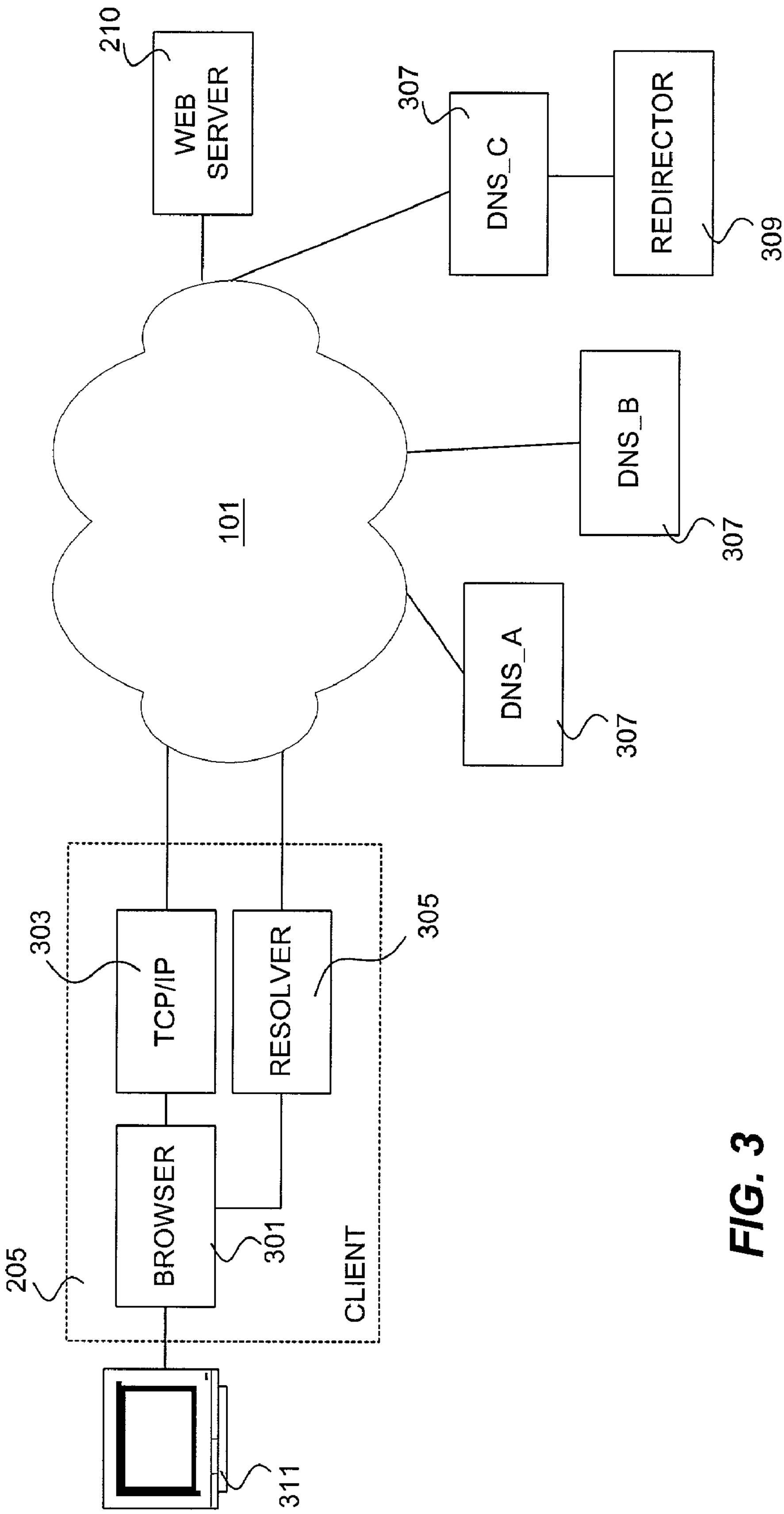

210
WEB SERVER
307
DNS_C
REDIRECTOR
309
101
DNS_B
307
DNS_A
307
303
TCP/IP
RESOLVER
305
BROWSER
301
205
CLIENT
311

FIG. 3

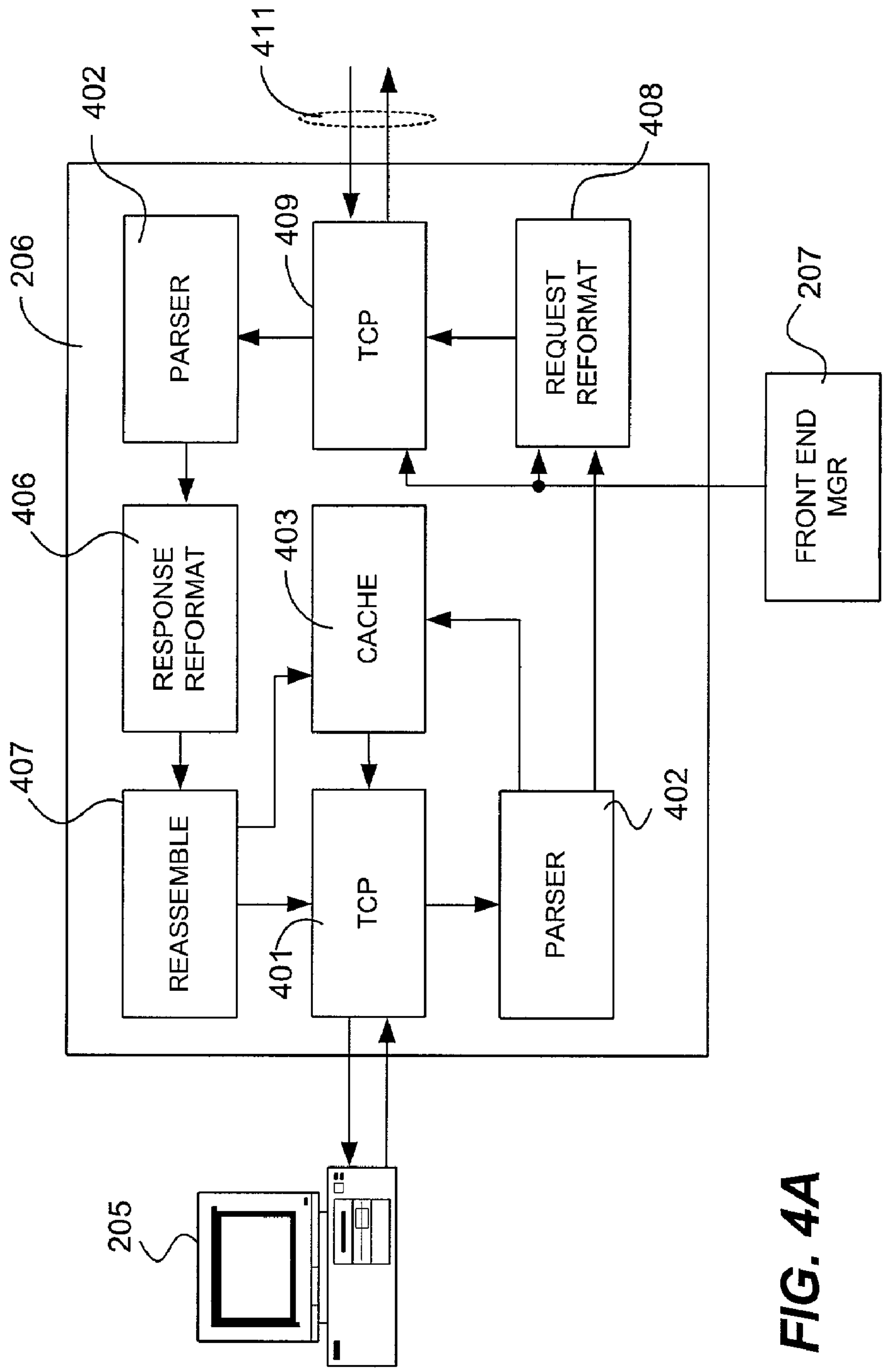

411
402
408
206
409
PARSER
TCP
REQUEST REFORMAT
207
FRONT END MGR
406
403
RESPONSE REFORMAT
CACHE
407
402
REASSEMBLE
TCP
PARSER
401
205

FIG. 4A

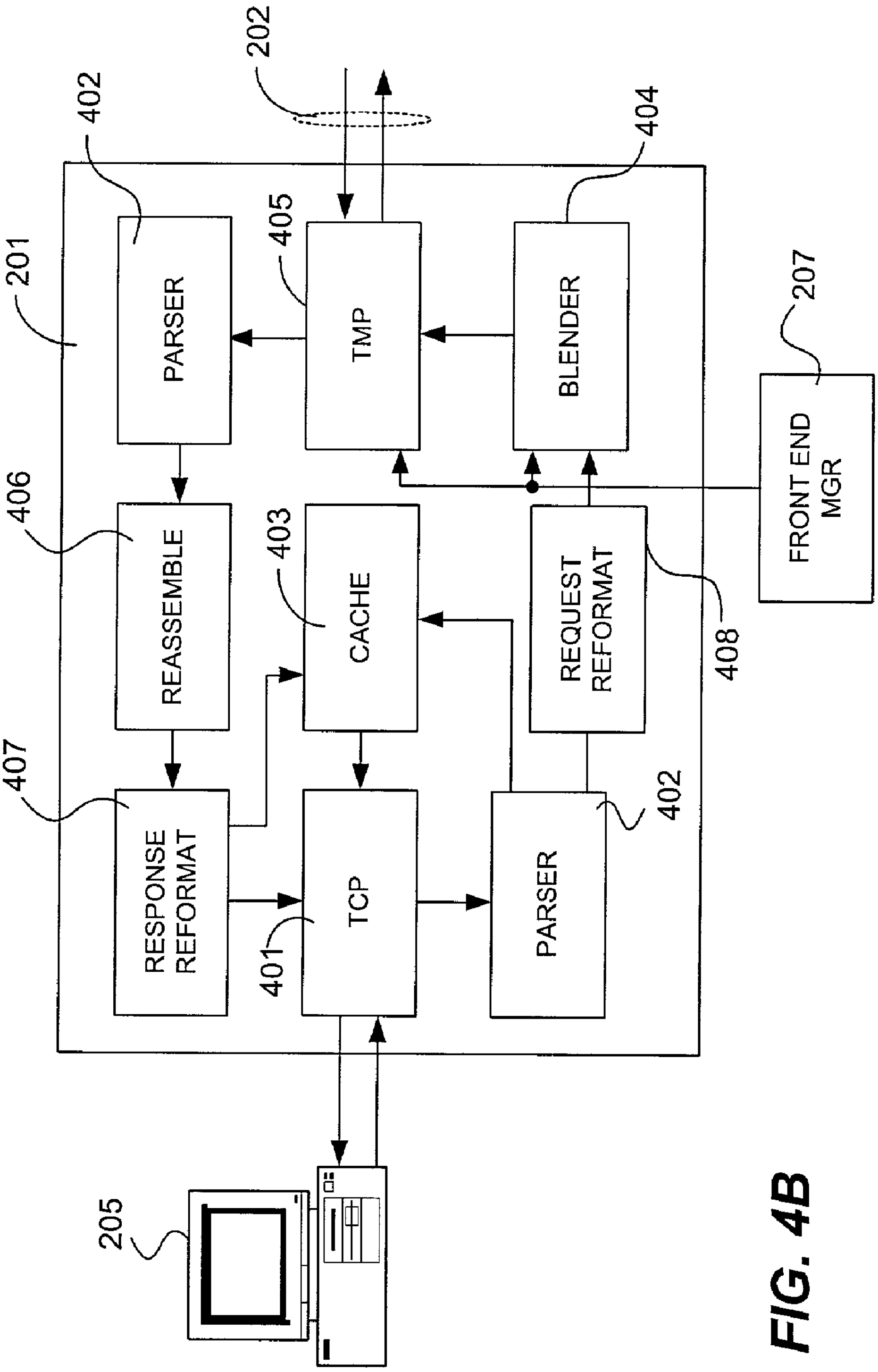

202
402
404
405
201
PARSER
TMP
BLENDER
207
FRONT END MGR
406
REASSEMBLE
403
CACHE
REQUEST REFORMAT
408
407
RESPONSE REFORMAT
TCP
PARSER
402
401
205

FIG. 4B

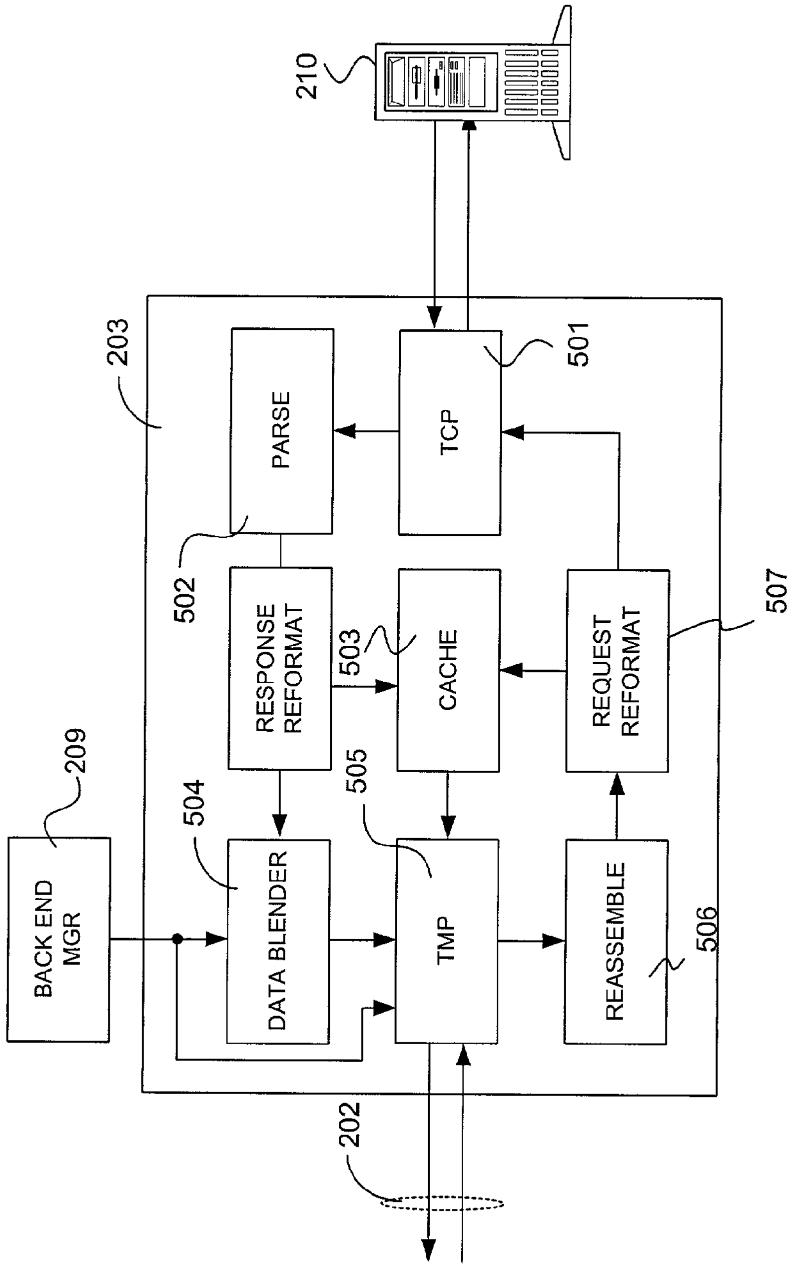

210
203
PARSE
TCP
501
502
RESPONSE REFORMAT
503
CACHE
REQUEST REFORMAT
507
209
BACK END MGR
504
DATA BLENDER
505
TMP
REASSEMBLE
506
202

FIG. 5

SYSTEM AND METHOD FOR REFORMATTING DATA TRAFFIC

RELATED APPLICATIONS

[0001] The present invention claims priority from U.S. Provisional Patent Application No. 60/197,490 entitled CONDUCTOR GATEWAY filed on Apr. 17, 2000.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates, in general, to network information access and, more particularly, to software, systems and methods for reformatting request and response traffic in a data communication system.

[0004] 2. Relevant Background

[0005] Increasingly, business data processing systems, entertainment systems, and personal communications systems are implemented by computers across networks that are interconnected by internetworks (e.g., the Internet). The Internet is rapidly emerging as the preferred system for distributing and exchanging data. Data exchanges support applications including electronic commerce, broadcast and multicast messaging, videoconferencing, gaming, and the like.

[0006] Currently, many Internet services are implemented as client-server systems. The client is typically implemented as a web browser application executing on a network-connected workstation or personal computer, although mail, news, file transfer and other Internet services are relatively common. The server is typically implemented as a web server at a fixed network address. A client enters a uniform resource locator (URL) or selects a link pointing to a URL where the URL identifies the server and particular content from the server that is desired. The client request traverses the network to be received by the server.

[0007] The server then obtains data necessary to compose a response to the client request. For example, the response may comprise a hypertext markup language (HTML) document in a web-based application. HTML and other markup language documents comprise text, graphics, active components, as well as references to files and resources at other servers. In the case of static web pages, the web server may simply retrieve the page from a file system, and send it in an HTTP response packet using conventional TCP/IP protocols and interfaces. In the case of dynamically generated pages, the web server obtains data necessary to generate a responsive page, typically through one or more database accesses. The web server then generates a page, typically a markup language document, that incorporates the retrieved data. Once generated, the web server sends the dynamic page in a manner similar to a static page.

[0008] Characteristically, web documents include hyperlinks which comprise pointers that, when selected, cause the user's browser to access additional Internet resources identified by the hyperlink. The references contained within hyperlinks may be absolute (e.g., contain a fully qualified URL to the specified resource) or relative (e.g., contain information that is relative to the current page being viewed). Relative and absolute addressing are, in theory, functionally equivalent to the client, but, in practice, may cause the systems involved in accessing Internet resources to behave differently. Hence, it is desirable to be able to rewrite links within hypertext documents.

[0009] HTML documents, as well as other Internet resources, include a variety of formatting options that affect the manner in which client machines behave. For example, a document may include directly or by reference an image file stored on the server as a bitmap, compressed bitmap, JPEG, or other available image format. However, a client can only display images for which it has installed complementary viewing software. Moreover, there may be physical limitations in the display size, color density, or other feature that prohibit accurate or useful rendering of a particular resource on a particular client.

[0010] For many client devices, it is desirable to minimize the code size and, therefore, provide a minimal set of image viewing applications. Client devices may have limited processing power in which case it is undesirable to execute complex image processing and rendering processes on the client device to reformat the network resources into a useable format. These difficulties create significant barriers to deployment of new client device types as the device architecture is constrained to a degree by the format of the data that it is intended to be displayed.

[0011] Hence, there is a continuing difficulty in matching the format in which Internet resources exist to the format preferred by the clients that desire access to the Internet resource. While the problem is described in terms of graphics files, it is in fact more pervasive. A particular client may be unable to execute Java, for example, where the Internet resource includes Java resources. In such cases, it would be desirable to reformat the resource so that it was executable on the client. A need exists for systems and methods for systematically reformatting network resources with little or no effort on the part of site owners in a manner that frees client devices from constraints imposed by the network resource format.

[0012] One problem with existing systems is that the web server activities required to generate a page consume significant computing resources within the server. Web servers have limited resources (e.g., buffers, ports, etc.) that must be shared amongst the tasks of maintaining connections, processing requests, accessing data, and rendering pages. Web servers can become overburdened and fail when their limited connection and processing resources are exceeded. The server interface often becomes a critical bottleneck in web site performance. To the extent reformatting resources by a server is even possible, the additional burden placed on the server is undesirable.

SUMMARY OF THE INVENTION

[0013] Briefly stated, the present invention involves a system for delivering network resources involving establishing communication between two computers connected via a network such as request-response traffic between a client and a server. Data contained within the request/response traffic is reformatted at least once in a first intermediary computer between the client and server.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] **FIG. 1** illustrates a general distributed computing environment in which the present invention is implemented;

[0015] **FIG. 2A** shows in block-diagram form significant components of a system in accordance with the present invention;

[0016] **FIG. 2B** shows in block-diagram form significant components of an alternative system in accordance with the present invention;

[0017] **FIG. 3** shows a domain name system used in an implementation of the present invention;

[0018] **FIG. 4A** shows components of **FIG. 2A** in greater detail;

[0019] **FIG. 4B** illustrates components of **FIG. 2B** in greater detail; and

[0020] **FIG. 5** shows back-end components of **FIG. 2B** in greater detail.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0021] The present invention is illustrated and described in terms of a distributed computing environment such as an enterprise computing system using public communication channels such as the Internet. However, an important feature of the present invention is that it is readily scaled upwardly and downwardly to meet the needs of a particular application. Accordingly, unless specified to the contrary, the present invention is applicable to significantly larger, more complex network environments, including wireless network environments, as well as small network environments such as conventional LAN systems.

[0022] In general, the present invention provides a set of systems and methods that effect reformatting of data as it is exchanged between two or more network-connected computers such as a client computer and a server. While a client-server connection is a common example, the present invention is applicable to data exchange between peers as well. Moreover, the present invention is described in terms of request-response data exchanges typical in the Internet, but is readily applied to other types of data exchanges such as streaming, broadcast, multicast, and other synchronous and asynchronous message exchange methodologies. In this manner, the server need not be aware of any peculiarities of the client device that may be required to present its resources in a useable fashion on the client. Likewise, the client device need not be aware of or constrained by the limitations of the server or the format of the resources provided by the server.

[0023] Essentially, an intermediary server is placed in communication with the client and server to participate in the request/response traffic between the client and server. In this position, the intermediary can be given specific knowledge of the configuration, capabilities and preferred formats of both the clients and servers. In a particular implementation, the intermediary server is implemented by a front-end computer and a back-end computer that are coupled over a network. This enables either or both of the front-end and back-end computers to perform the reformatting functions as needed.

[0024] The reformatting functions involve a range of reformatting applied to response messages from a server to a client, including, but not limited to:

[0025] modifying links;

[0026] converting graphics formats;

[0027] changing display size;

[0028] modifying image color depth, brightness, contrast or the colors themselves

[0029] compressing data;

[0030] translating text;

[0031] removing rich content such as images and audio file;

[0032] performing optical character or speech recognition;

[0033] encrypting data;

[0034] compiling/converting active content; and

[0035] converting from HTML to XML.

[0036] converting between a first script format and a second script format (e.g., Java script to ActiveX and vice versa).

[0037] Although less frequently needed, reformatting can also be applied to request messages. For example, an HTTP request can be reformatted into a structured query language (SQL) request that can be applied to a database. Further, client requests may include large data sets or parameters that benefit from compression, encryption, and/or reformatting of some type. The present invention is contemplated to encompass all types of reformatting performed in an intermediary server.

[0038] **FIG. 1** shows an exemplary computing environment **100** in which the present invention may be implemented. Environment **100** includes a plurality of local networks such as Ethernet network **102**, FDDI network **103** and Token Ring network **104**. Essentially, a number of computing devices and groups of devices are interconnected through a network **101**. For example, local networks **102**, **103** and **104** are each coupled to network **101** through routers **109**. LANs **102**, **103** and **104** may be implemented using any available topology and may implement one or more server technologies including, for example UNIX, Novell, or Windows NT networks, or peer-to-peer type network. Each network will include distributed storage implemented in each device and typically includes some mass storage device coupled to or managed by a server computer. Network **101** comprises, for example, a public network such as the Internet or another network mechanism such as a fibre channel fabric or conventional WAN technologies.

[0039] Local networks **102**, **103** and **104** include one or more network appliances **107**. One or more network appliances **107** may be configured as an application and/or file server. Each local network **102**, **103** and **104** may include a number of shared devices (not shown) such as printers, file servers, mass storage and the like. Similarly, devices **111** may be shared through network **101** to provide application and file services, directory services, printing, storage, and the like. Routers **109** provide a physical connection between the various devices through network **101**. Routers **109** may implement desired access and security protocols to manage access through network **101**.

[0040] Network appliances **107** may also couple to network **101** through public switched telephone network **108** using copper or wireless connection technology. In a typical environment, an Internet service provider **106** supports a connection to network **101** as well as PSTN **108** connections to network appliances **107**.

[0041] Network appliances **107** may be implemented as any kind of network appliance having sufficient computational function to execute software needed to establish and use a connection to network **101**. Network appliances **107** may comprise workstation and personal computer hardware executing commercial operating systems such as Unix variants, Micrsosoft Windows, MacIntosh OS, and the like. At the same time, some appliances **107** comprise portable or handheld devices using wireless connections through a wireless access provider such as personal digital assistants and cell phones executing operating system software such as PalmOS, WindowsCE, EPOC and the like. Moreover, the present invention is readily extended to network devices such as office equipment, vehicles, and personal communicators that make occasional connection through network **101**.

[0042] Each of the devices shown in **FIG. 1** may include memory, mass storage, and a degree of data processing capability sufficient to manage their connection to network **101**. The computer program devices in accordance with the present invention are implemented in the memory of the various devices shown in **FIG. 1** and enabled by the data processing capability of the devices shown in **FIG. 1**. In addition to local memory and storage associated with each device, it is often desirable to provide one or more locations of shared storage such as disk farm (not shown) that provides mass storage capacity beyond what an individual device can efficiently use and manage. Selected components of the present invention may be stored in or implemented in shared mass storage.

[0043] One feature of the present invention is that front-end servers **201** (shown in **FIG. 2B**) and/or intermediate servers **206** (shown in **FIG. 2A**) are implemented as an interchangeable pool of servers, any one of which may be dynamically configured to provide the application services. The embodiments of **FIG. 2A** and **FIG. 2B** are not strictly alternative as they may coexist in a network environment. A redirection mechanism, shown in **FIG. 3**, is enabled to select from an available pool of front-end servers **201** and intermediate servers **206** and direct client request packets from the originating web server to a selected front-end server **201** or intermediary server **206**.

[0044] In the case of web-based environments, front-end **201**, intermediary server **206**, and back-end server **203** can be implemented using custom or off-the-shelf web server software. For purposes of this document, a web server is a computer running server software coupled to the World Wide Web (i.e., "the web") that delivers or serves web pages. The web server has a unique IP address and accepts connections in order to service requests by sending back responses. A web server differs from a proxy server or a gateway server in that a web server has resident a set of resources (i.e., software programs, data storage capacity, and/or hardware) that enable it to execute programs to provide an extensible range of functionality such as generating web pages, accessing remote network resources, analyzing contents of packets, reformatting request/response traffic and the like using the resident resources. In contrast, a proxy simply forwards request/response traffic on behalf of a client to resources that reside elsewhere, or obtains resources from a local cache if implemented. A web server in accordance with the present invention may reference external resources of the same or different type as the services requested by a user, and reformat and augment what is provided by the external resources in its response to the user. Commercially available web server software includes Microsoft Internet Information Server (IIS), Netscape Netsite, Apache, among others.

[0045] In the embodiment of **FIG.** 2A, intermediary servers **206** interact directly with server(s) **210-212**. In the embodiment of **FIG.** 2B, intermediary server **206** is implemented as front-end computer **201** and a back-end computer **203**. Front-end server **201** establishes and maintains an enhanced communication channel with a backend server **203**. In either embodiment, intermediary server **206**, front-end **201** and/or back-end **203** operate to reformat request and/or response traffic flowing between a client **205** and a server **210-212**. The reformatted request (response) is sent on to either server **210-212** or client **205**. Preferably, a cache structure such as cache **204** shown in **FIG. 2A** is used to store reformatted response content so that it can be delivered directly from cache **204** without reference to a server **210-212** to offer improved performance. Alternatively, cache **204** may hold response content before it is reformatted, in which case content used from cache **204** is reformatted after retrieval from cache but before transmission to a requesting client **205**.

[0046] In the specific examples herein client **205** comprises a network-enabled graphical user interface such as a World Wide Web browser. However, the present invention is readily extended to client software other than conventional World Wide Web browser software. Any client application that can access a standard or proprietary user level protocol for network access is a suitable equivalent. Examples include client applications that act as front ends for file transfer protocol (FTP) services, voice over Internet protocol (VOIP) services, network news protocol (NNTP) services, multi-purpose internet mail extensions (MIME) services, post office protocol (POP) services, simple mail transfer protocol (SMTP) services, as well as Telnet services. In addition to network protocols, the client application may serve as a front-end for a network application such as a database management system (DBMS) in which case the client application generates query language (e.g., structured query language or "SQLI") messages. In wireless appliances, a client application functions as a front-end to a wireless application protocol (WAP) service or the like.

[0047] **FIG. 2B** illustrates an embodiment in which intermediary server **206** is implemented by cooperative action of a front-end computer **201** and a back-end computer **203**. Reformatting processes are performed by front-end **201**, back-end **203**, or both. As in the embodiment of **FIG.** 2A, reformatting includes rewriting links, converting graphics formats, altering fonts, font sizes, image sizes, color density, compiling/converting program constructs and the like.

[0048] Front-end mechanism **201** serves as an access point for client-side communications. In one example, front-end **201** comprises a computer that sits "close" to clients **205**. By "close", "topologically close" and "logically close" it is meant that the average latency associated with a connection between a client **205** and a front-end **201** is less than the average latency associated with a connection between a client **205** and servers **210-212**. Desirably, front-end computers have as fast a connection as possible to the clients **205**. For example, the fastest available connection may be implemented in point of presence (POP) of an Internet service provider (ISP) **106** used by a particular client **205**. However, the placement of the front-ends **201** can limit the number of browsers that can use them. Because of this, in some applications it is more practical to place one front-end computer in such a way that several POPs can connect to it. Greater distance between front-end **201** and clients **205** may be desirable in some applications as this distance will allow for selection amongst a greater number front-ends **201** and thereby provide significantly different routes to a particular back-end **203**. This may offer benefits when particular routes and/or front-ends become congested or otherwise unavailable.

[**0049**] Transport mechanism **202** is implemented by cooperative actions of the front-end **201** and back-end **203**. Back-end **203** processes and directs data communication to and from server(s) **210-212**. Transport mechanism **202** communicates data packets using a proprietary protocol over the public Internet infrastructure in the particular example. Hence, the present invention does not require heavy infrastructure investments and automatically benefits from improvements implemented in the general-purpose network **101**. Unlike the general-purpose Internet, front-end **201** and back-end **203** are programmably assigned to serve accesses to a particular server **210-212** at any given time.

[**0050**] It is contemplated that any number of front-end and back-end mechanisms may be implemented cooperatively to support the desired level of service required by the server owner. The present invention implements a many-to-many mapping of front-ends to back-ends. Because the front-end to back-end mappings can by dynamically changed, a fixed hardware infrastructure can be logically reconfigured to map more or fewer front-ends to more or fewer back-ends and web sites or servers as needed.

[**0051**] A particular advantage of the architectures shown in **FIG. 2**A and **FIG. 2B** is that they are readily scaled. In accordance with the present invention, not only can the data itself be distributed, but the functionality and behavior required to reformat content and resources is readily and dynamically ported to any of a number of intermediary computers **206** and/or front-ends **201** and/or back-ends **203**. In contrast, conventional web server systems require additional hardware and/or software resources scale. In this manner, any number of client machines **205** may be supported. In a similar manner, a web site owner may choose use multiple servers **210-212** that are co-located or distributed throughout network **101**. To avoid congestion, additional front-ends **201** and/or intermediary servers **206** may be implemented or assigned to particular web sites. Each front-end **201** and/or intermediary server **206** is dynamically re-configurable by updating address parameters to serve particular web sites. Client traffic is dynamically directed to available front-ends **201** to provide load balancing.

[**0052**] In the examples, dynamic configuration is implemented by a front-end manager component **207** (shown only in **FIG. 2B**) that communicates with multiple front-ends **201** and/or intermediary servers **206** to provide administrative and configuration information to front-ends **201**. Each front-end **201** includes data structures for storing the configuration information, including information identifying the IP addresses of servers **210-212** to which they are currently assigned. Other administrative and configuration information stored in front-end **201** and/or intermediary servers **206** may include information for prioritizing particular data, quality of service information and the like.

[**0053**] Similarly, additional back-ends **203** can be assigned to a web site to handle increased traffic. Back-end manager component **209** couples to one or more back-ends **203** to provide centralized administration and configuration service. Back-ends **203** include data structures to hold current configuration state, quality of service information and the like. In the particular examples, front-end manager **207** and back-end manager **209** serve multiple servers **210-212** and so are able to manipulate the number of front-ends and back-ends assigned to each server **210** by updating this configuration information. When the congestion for the server **210** subsides, the front-end **201**, back-end **203**, and/or intermediary server **206** can be reassigned to other, busier servers. These and similar modifications are equivalent to the specific examples illustrated herein.

[**0054**] In order for a client **205** to obtain service from a front-end **201** or intermediate server **206**, it must first be directed to a front-end **201** or intermediate server **206** that can provide the desired service. Preferably, client **205** initiates all transactions as if it were contacting the originating server **210**. **FIG. 3** illustrates a domain name server (DNS) redirection mechanism that illustrates how a client **205** is connected to a front-end **201**. The DNS systems is defined in a variety of Internet Engineering Task Force (IETF) documents such as RFC0883, RFC 1034 and RFC 1035 which are incorporated by reference herein. In a typical environment, a client **205** executes a browser **301**, TCp/IP stack **303**, and a resolver **305**. For reasons of performance and packaging, browser **301**, TCP/IP stack **303** and resolver **305** are often grouped together as routines within a single software product.

[**0055**] Browser **301** functions as a graphical user interface to implement user input/output (I/O) through monitor **311** and associated keyboard, mouse, or other user input device (not shown). Browser **301** is usually used as an interface for web-based applications, but may also be used as an interface for other applications such as email and network news, as well as special-purpose applications such as database access, telephony, and the like. Alternatively, a special-purpose user interface may be substituted for the more general-purpose browser **301** to handle a particular application.

[**0056**] TCP/IP stack **303** communicates with browser **301** to convert data between formats suitable for browser **301** and IP format suitable for Internet traffic. TCP/IP stack also implements a TCP protocol that manages transmission of packets between client **205** and an Internet service provider (ISP) or equivalent access point. IP protocol requires that each data packet include, among other things, an IP address identifying a destination node. In current implementations the IP address comprise a 32-bit value that identifies a particular Internet node. Non-IP networks have similar node addressing mechanisms. To provide a more user-friendly addressing system, the Internet implements a system of domain name servers that map alpha-numeric domain names to specific IP addresses. This system enables a name space that is more consistent reference between nodes on the Internet and avoids the need for users to know network identifiers, addresses, routes and similar information in order to make a connection.

[**0057**] The domain name service is implemented as a distributed database managed by domain name servers (DNSs) **307** such as DNS_A, DNS_B and DNS_C shown in **FIG. 3**. Each DNS relies on <domain name:IP>address mapping data stored in master files scattered through the hosts that use the domain system. These master files are updated by local system administrators. Master files typically comprise text files that are read by a local name server, and hence become available through the name servers **307** to users of the domain system.

[**0058**] The user programs (e.g., clients **205**) access name servers through standard programs such as resolver **305**. Resolver **305** includes an address of a DNS **307** that serves as a primary name server. When presented with a reference to a domain name for a server **210-212**, resolver **305** sends a request to the primary DNS (e.g., DNS_A in **FIG. 3**). The primary DNS **307** returns either the IP address mapped to that domain name, a reference to another DNS **307** which has the mapping information (e.g., DNS_{13} B in **FIG. 3**), or a partial IP address together with a reference to another DNS that has more IP address information. Any number of DNS-to-DNS references may be required to completely determine the IP address mapping.

[**0059**] In this manner, the resolver **305** becomes aware of the IP address mapping which is supplied to TCP/IP component **303**. Client **205** may cache the IP address mapping for future use. TCP/IP component **303** uses the mapping to supply the correct IP address in packets directed to a particular domain name so that reference to the DNS system need only occur once.

[**0060**] In accordance with the present invention, at least one DNS server **307** is owned and controlled by system components of the present invention. When a user accesses a network resource (e.g., a database), browser **301** contacts the public DNS system to resolve the requested domain name into its related IP address in a conventional manner. In a first embodiment, the public DNS performs a conventional DNS resolution directing the browser to an originating server **210-212** and server **210-212** performs a redirection of the browser to the system owned DNS server (i.e., DNC_C in **FIG. 3**). In a second embodiment, domain:address mappings within the DNS system are modified such that resolution of the of the originating server's domain automatically return the address of the systemowned DNS server (DNS_C). Once a browser is redirected to the system-owned DNS server, it begins a process of further redirecting the browser **301** to the best available front-end **201**.

[**0061**] Unlike a conventional DNS server, however, the system-owned DNS C in **FIG. 3** receives domain:address mapping information from a redirector component **309**.

[**0062**] Redirector **309** is in communication with front-end manager **207** and back-end manager **209** to obtain information on current front-end and back-end assignments to a particular server **210-212**. A conventional DNS is intended to be updated infrequently by reference to its associated master file. In contrast, the master file associated with DNS_C is dynamically updated by redirector **309** to reflect current assignment of front-end **201** and back-end **203**. In operation, a reference to servers **210-212** may result in an IP address returned from DNS_C that points to any selected front-end **201** that is currently assigned to servers **210-212**. Likewise, servers **210-212** can identify a currently assigned back-end **203** by direct or indirect reference to DNS_C.

[**0063**] Despite the efficiency of the mechanisms shown in **FIG. 3**, redirection does take some time and it may be preferable to send subsequent requests for a particular server **210-212** directly to an assigned front-end **201** or intermediary server **206** without redirection. When a web page includes links with absolute references the browser **301** may attempt DNS resolution each time a link is followed. To prevent this, one embodiment of the present invention rewrites these links as a part of its reformatting process. In this manner, even though the server contains only a page with absolute references, the page delivered to a client contains relative references.

[**0064**] **FIG. 4A** illustrates a first embodiment in which a single intermediary computer **206** is used, whereas **FIG. 4B** and **FIG. 5** illustrate a second embodiment where both front-end **201** and back-end **203** are used to implement the intermediary server **206**. In the embodiment of **FIG. 4A** the intermediary server **206** may be located topologically near the client **205** or servers **210-212**—either alternative provides some advantage and the choice of location is made to meet the needs of a particular application. Like identified components are substantially equivalent in **FIG. 4A**, **FIG. 4B** and **FIG. 5** and for ease of understanding are not duplicatively described herein. Also, the components shown in **FIG. 4A** and **FIG. 4B** are optimized for web-based applications. Appropriate changes to the components and protocols are made to adapt the specific examples to other protocols and data types.

[**0065**] Requests from client **205** are received by a TCP unit **401**. TCP component **401** includes devices for implementing physical connection layer and Internet protocol (IP) layer functionality. Current IP standards are described in IETF documents RFC0791, RFC0950, RFC0919, RFC0922, RFC792, RFC1112 that are incorporated by reference herein. For ease of description and understanding, these mechanisms are not described in great detail herein. Where protocols other than TCP/IP are used to couple to a client **205**, TCP component **401** is replaced or augmented with an appropriate network protocol process.

[**0066**] TCP component **401** communicates TCP packets with one or more clients **205**. Preferably, TCP component **401** creates a socket for each request, and returns a received response through the same socket. Received packets are coupled to parser **402** where the Internet protocol (or equivalent) information is extracted. TCP is described in IETF RFC0793 which is incorporated herein by reference. Each TCP packet includes header information that indicates addressing and control variables, and a payload portion that holds the user-level data being transported by the TCP packet. The user-level data in the payload portion typically comprises a user-level network protocol datagram.

[**0067**] Parser **402** analyzes the payload portion of the TCP packet. In the examples herein, HTTP is employed as the user-level protocol because of its widespread use and the advantage that currently available browser software is able to readily use the HTTP protocol. In this case, parser **402** comprises an HTTP parser. More generally, parser **402** can be implemented as any parser-type logic implemented in hardware or software for interpreting the contents of the payload portion. Parser **402** may implement file transfer protocol (FTP), mail protocols such as simple mail transport protocol (SMTP) and the like. Any user-level protocol, including proprietary protocols, may be implemented within the present invention using appropriate modification of parser **402**.

[**0068**] Where the request data information is amenable to reformatting, it is sent to request reformat unit **408**. It is contemplated that client requests in many environments are small, carry little data. In such cases it may be desirable to omit HTTP parser **402** and request reformat unit **408** as the requests may rarely need reformatting. However, other applications may require an HTTP request, for example, to be reformatted to a query language request such as SQL. Also, parser **402** may be useful where intermediary server **206** performs other functions, such as prioritization, encryption, compression, and the like that require request analysis even where request reformatting is not performed.

[**0069**] To improve performance, front-end **201** optionally includes a caching mechanism **403**. Cache **403** may be implemented as a passive cache that stores frequently and/or recently accessed web site content or as an active cache that stores web site content that is anticipated to be accessed. Upon receipt of a TCP packet, HTTP parser **402** determines if the packet is making a request for data within cache **403**. If the request can be satisfied from cache **403** the data is supplied directly without reference to servers **210-212** (i.e., a cache hit). Cache **403** implements any of a range of management functions for maintaining fresh content. For example, cache **403** may invalidate portions of the cached content after an expiration period specified with the cached data or by data sever **210-212**. Also, cache **403** may proactively update the cache contents even before a request is received for particularly important or frequently used data from servers **210-212**. Cache **403** evicts information using any desired algorithm such as least recently used, least frequently used, first in/first out, or random eviction. When the requested data is not within cache **403**, a request is processed to servers **210-212**, and the returned data may be stored in cache **403**.

[**0070**] A request for data that is not within cache **403** (or if optional cache **403** is not implemented) will require a reference to server **210-212**. Some packets will comprise data that may need to be supplied to server **210-212** (e.g., customer credit information, form data and the like). In these instances, HTTP parser **402** couples to transport component **409** The request or reformatted request is passed to transport component **409** for communication to server **210-212** over channel **411**. In a particular embodiment, transport component **409** is implements a TCP/IP layer suitable for transport over the Internet or other IP network. Transport component **409** creates a socket connection for each request that corresponds to the socket created in transport component **401**. This arrangement enables responses to be matched to requests that generated the responses. Channel **411** is compatible with an interface to servers **210-212** which may include Ethernet, Fibre channel, or other available physical and transport layer interfaces.

[**0071**] Server **210-212** returns responses to transport component **409** and supplies responses to parser **402**. Parser **402** implements similar processes with the HTTP response packets as described hereinbefore with respect to request packets. Significantly, parser **402** identifies the data portion of response packets to allow the data portion to be manipulated by reformat component **406**.

[**0072**] Response reformat component **406** examines the data portion of response packets to determine when reformatting is appropriate. Reformatting is appropriate when, for example, the response comprises an HTML document having absolute references in contained links. In this case, reformat component **406** rewrites the links with relative references. Reformatting may also be appropriate when the response includes a graphic format that cannot be interpreted by the client **205** or may not be appropriate to forward to client **205** due to constrained bandwidth. In such a case, a bitmap file might be converted to a JPEG or GIF file. It is contemplated that reformatting will take place at a wide variety of manners and granularity ranging from reformatting of contained links to substantively reformatting an entire document by changing sizes and layout so that it performs its desired function when presented to a requesting client **205**. Component **406** is optionally used to implement data decompression where appropriate, decryption, and handle caching when the returning data is of a cacheable type.

[**0073**] Preferably, intermediary server **206** has some knowledge of client **205**'s capabilities, needs and preferences in order to make intelligent decisions as to when reformatting is appropriate. This knowledge can be supplied by client **205** as a cookie or parameter in the request itself. Alternatively, this knowledge can be maintained in a user database (not shown) within or accessible to intermediary **206** where the user database associates user identification or network address with particular types of reformatting that are to be performed. Intermediary **206** matches request/response traffic between a particular client **205** and server **210-212** and so can apply the desired reformatting in an intelligent manner based on a particular client's needs.

[**0074**] HTTP component **407** reassembles the response, including any reformatted data, into a format suitable for use by client **205**, which in the particular examples herein comprises a web page transported as an HTTP packet. The HTTP packet is sent to transport component **401** for communication to client **205** on the socket opened when the corresponding request was received. In this manner, from the perspective of client **205**, the request has been served by originating server **210-212**.

[**0075**] In the embodiment of **FIG. 4A** and **FIG. 5**, intermediary server **206** shown in **FIG. 2A** is implemented by front-end computer **201** and back-end computer **203**. A front-end computer **201** refers to a computer located at the client side of network **101** whereas a back-end computer **203** refers to a computer located at the server side of network **101**. This arrangement enables reformatting to be performed at either or both computers. Hence, in addition to reformatting data to serve needs of clients **205** and server **210-212**, data can be reformatted to improve transport across the communication link **202** coupling front-end **201** and back-end **203**. For example, back-end **203** can compress graphics and front-end can apply a corresponding decompression so that client **205** receives the data in substantially the same form as provided by server **210-212**, but both client **205** and server **210-212** benefit from improved transport characteristics.

[**0076**] Optionally, front-end **201**, back-end **203**, and intermediary computer **206** implement security processes, compression processes, encryption processes and the like to condition the received data for improved transport performance and/or provide additional functionality. These processes may be implemented within any of the functional components (e.g., data blender **404**) or implemented as separate functional components within front-end **201**, back-end **203** or intermediary **206**. Also, parser **402** may identify priority information transmitted with a request. The prioritization information may be provided by the owners of server **210-212**, for example, and may be dynamically altered, statically set, or updated from time to time to meet the needs of a particular application.

[**0077**] In the embodiment of **FIG. 4**B and **FIG. 5**, blenders **404** and **504** slice and/or coalesce the data portions of the received packets into more desirable "TMP™ units" that are sized for transport through the TMP mechanism **202**. The data portion of TCP packets may range in size depending on client **205** and any intervening links coupling client **205** to TCP component **401**. Moreover, where compression or other reformatting is applied, the data will vary in size depending on the reformatting processes. Data blender **404** receives information from front-end manager **207** that enables selection of a preferable TMP packet size. Alternatively, a fixed TMP packet size can be set that yields desirable performance across TMP mechanism **202**. Data blenders **404** and **504** also mark the TMP units so that they can be re-assembled at the receiving end.

[**0078**] Data blender **404** may also serve as a buffer for storing packets from all appliances **177** that are associated with front-end **201**. In accordance with the present invention, data blender **404** may associate a prioritization value with each packet.

[**0079**] TMP™ mechanisms **405** and **505** implement the transport morphing protocol™ (TMP™) packets used in the system in accordance with the present invention. Transport morphing protocol and TMP are trademarks or registered trademarks of Circadence Corporation in the United States and other countries. Front-end TMP mechanism **405** in cooperation with a corresponding back-end TMP mechanism **505** shown in **FIG. 5** are computer processes that implement the end points or sockets of TMP link **202**. The TMP mechanism in accordance with the present invention creates and maintains a stable connection between two processes for high-speed, reliable, adaptable communication.

[**0080**] Another feature of TMP is its ability to channel numerous TCP connections through a single TMP pipe **202**. The environment in which TMP resides allows multiple TCP connections to occur at one end of the system. These TCP connections are then combined into a single TMP connection. The TMP connection is then broken down at the other end of the TMP pipe **202** in order to traffic the TCP connections to their appropriate destinations. TMP includes mechanisms to ensure that each TMP connection gets enough of the available bandwidth to accommodate the multiple TCP connections that it is carrying.

[**0081**] An advantage of TMP as compared to traditional protocols is the amount of information about the quality of the connection that a TMP connection conveys from one end to the other of a TMP pipe **202**. As often happens in a network environment, each end has a great deal of information about the characteristics of the connection in one direction, but not the other. By knowing about the connection as a whole, TMP can better take advantage of the available bandwidth.

[**0082**] In addition to the reformatting functions described above, reformatting may comprise embedding information within request/response traffic. As noted above, most web pages make reference to one or more files that include text, graphics, or program code such as applets or scripts. When a web page is delivered to a web browser, the browser reads these references, makes new requests to retrieve the referenced information, then renders the page. This can result in each web page requiring tens of server transactions.

[**0083**] In accordance with the present invention, these references can be resolved by the front-end **201**, back-end **203**, or intermediary **206** and embedded or in-lined into the response. After reformatting, the page can be delivered to client **205** in a manner that is akin to a static web page in that the rendering browser need not make further requests. However, unlike a static page, the page has actually been dynamically generated according to the requirements of server **210-212**. This operation can reduce the number of request/response transactions required to generate a page, especially when some of the referenced data is included in cache **204**, front-end cache **403** or back-end cache **503**.

[**0084**] Another useful reformatting function involves language translation. Companies that desire to do business internationally often face significant challenges and expense in internationalizing network resources such as web sites. The most common solution is to maintain separate complete copies of the web site in each of a limited number of languages. In accordance with the present invention, reformatting may include automated translation services that convert text files from a first language into a second language. The automated translation can be implemented with any desired degree of accuracy using general-purpose translation processes or special-purpose translation processes specified by the owner of a web site.

[**0085**] In a similar manner, reformatting can change the communication mode of the data from one type to another. For example, a text file can be automatically translated to an audio speech file for delivery to sight impaired users. This augments reformatting to increase font sizes or change color schemes to make them more readily viewable by sight impaired users. In accordance with the present invention, these services can be offered without any involvement or extra work for the site owner. These services can be offered by the owner of an intermediary computer **206** on a subscription basis, for example, to subscribing users.

[**0086**] Another particular application of the present invention involves using the reformatting mechanisms to accomplish document conversion. There are a number of document standards for various word processing programs including Microsoft Word, Corel Wordperfect, postscript, portable document format, rich text format and the like. Clients must have installed a viewer and/or editor for the appropriate document format. The present invention is readily employed to convert from one document format to another so that the requesting client can use the material as intended on available word processing software.

[0087] In a similar manner to document conversion, reformatting in accordance with the present invention may be used to convert a file in a first user-level protocol or language to an alternative user-level protocol or language. For example, an HTML document may be reformatted to an XML or other markup language format, or may be reformatted to wireless application protocol (WAP) for display on WAP devices.

[0088] Reformatting may involve consideration of multiple data packets in the request/response stream. Transferring an entire multimedia file or document typically involves multiple response packets. In such cases it is contemplated that the intermediary server **206** may be configured to read and parse all data packets associated with a particular document, reassemble the document, reformat the document, and then break the formatted document into multiple data packets for transmission.

[0089] Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed. For example, while devices supporting HTTP data traffic are used in the examples, the HTTP devices may be replaced or augmented to support other public and proprietary protocols including FTP, NNTP, SMTP, SQL and the like. In such implementations the front-end **201** and/or back end **203** are modified to implement the desired protocol. Moreover, front-end **201** and back-end **203** may support different protocols such that the front-end **201** supports, for example, HTTP traffic with a client and the back-end supports a DBMS protocol such as SQL. Such implementations not only provide the advantages of the present invention, but also enable a client to access a rich set of network resources with minimal client software.

We claim:

1. A method for delivering network resources comprising the acts of:

establishing request-response traffic between a first and second computer; and

reformatting the request/response traffic at least once in at least one intermediary computer between the first and second computer.

2. The method of claim 1 wherein the first computer comprises a client and the second computer comprises a server, and the act of establishing request-response traffic comprises:

generating a client request specifying resources available on the server;

retrieving the specified resources;

generating a response to the client request in the server and at least one of the intermediary computers; and

forwarding the server response after reformatting from the at least one intermediary server to the client.

3. The method of claim 1 wherein the act of reformatting comprises converting graphic data within the request/response traffic from a first graphic format to a second graphic format.

4. The method of claim 1 wherein the act of reformatting comprises converting executable program constructs within the request/response traffic from a first format to a second format.

5. The method of claim 1 wherein the act of reformatting comprises converting between a Java script component and an ActiveX component.

6. The method of claim 1 wherein the act of reformatting comprises converting formatted text within the request/response traffic from a first format to a second format.

7. The method of claim 1 wherein the act of reformatting comprises converting text within the request/response traffic from a first language to a second language.

8. The method of claim 1 wherein the act of reformatting comprises converting hypertext links within the request/response traffic between an absolute form and a relative form.

9. The method of claim 1 wherein the act of reformatting comprises converting from a first markup language format to a second markup language format.

10. The method of claim 1 wherein the act of reformatting comprises converting a document from a first document format to a second document format.

11. The method of claim 1 wherein the act of reformatting comprises converting the data from a first compression level to a second compression level.

12. The method of claim 1 wherein the act of reformatting comprises considering special needs of the client during the reformatting.

13. The method of claim 1 further comprising: reformatting at least once in a second intermediary computer.

14. The method of claim 13 wherein the reformatting in the second intermediary computer undoes at least some of the reformatting performed in the first intermediary computer.

15. The method of claim 1 wherein the reformatting comprises reformatting data included in responses only.

16. The method of claim 1 wherein the reformatting comprises the acts of:

resolving links within the request/response traffic to identify network resources pointed to by the links;

retrieving resources pointed to by the links;

embedding resources pointed to by the links in-line with other data in the request/response traffic; and

forwarding the request/response traffic after embedding.

17. A system for communicating data between first and second computers, the system comprising:

a intermediary computer coupled to a network;

first connection components within the intermediary computer configured to communicate data traffic with the first computer;

second connection components within the intermediary computer configured to communicate data traffic with the second computer; and reformatting components within the intermediary computer configured to reformat at least some of the data traffic before the data traffic between the first and second computers.

18. The system of claim 17 wherein the reformatting components comprise a graphic conversion process.

19. The system of claim 17 wherein the reformatting components comprise a compiler.

20. The system of claim 17 wherein the reformatting components comprise a media file conversion process.

21. The system of claim 17 wherein the reformatting components comprise data compression processes.

22. The system of claim 17 wherein the reformatting components comprise processes converting documents from a first markup language to a second markup language.

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