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**Pashov**

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(54) **CROSS MACHINE REQUEST FORWARDING**

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(51) **Int. Cl.**

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|---|---|
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| ***H04L 45/58*** | (2022.01) |
| ***H04L 67/02*** | (2022.01) |
| ***H04L 69/22*** | (2022.01) |

(52) **U.S. Cl.**

CPC .............. ***G06F 9/545*** (2013.01); ***G06F 9/546*** (2013.01); ***H04L 45/58*** (2013.01); ***H04L 67/02*** (2013.01); ***H04L 69/22*** (2013.01)

(58) **Field of Classification Search**

CPC ......... G06F 9/545; G06F 9/546; H04L 45/58; H04L 67/02; H04L 69/22

See application file for complete search history.

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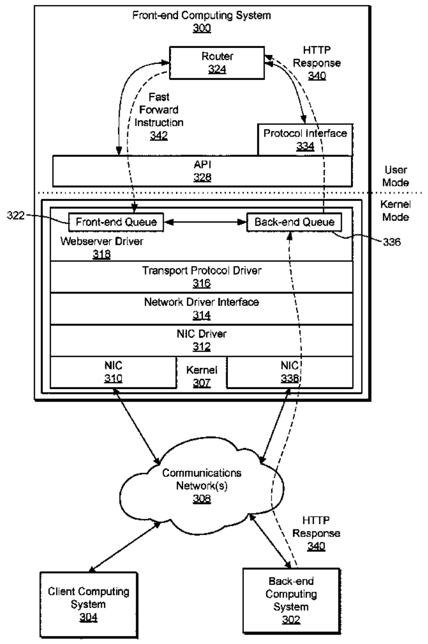
(57) **ABSTRACT**

A front-end computing system provides cross machine message forwarding through a kernel mode component. The message is received in a kernel mode queue of the front-end computing system. The message includes one or more headers and an entity body including one or more data blocks. A user mode router in the front-end computing system designates a computing system to process the message based at least in part on the one or more headers. The

(Continued)


Front-end Computing System 300
Router 324
HTTP Response 340
Fast Forward Instruction 342
Protocol Interface 334
API 328
User Mode
Kernel Mode
322
Front-end Queue
Back-end Queue
336
Webserver Driver 318
Transport Protocol Driver 316
Network Driver Interface 314
NIC Driver 312
NIC 310
Kernel 307
NIC 338
Communications Network(s) 308
HTTP Response 340
Client Computing System 304
Back-end Computing System 302

one or more data blocks are passed through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

**11 Claims, 7 Drawing Sheets**

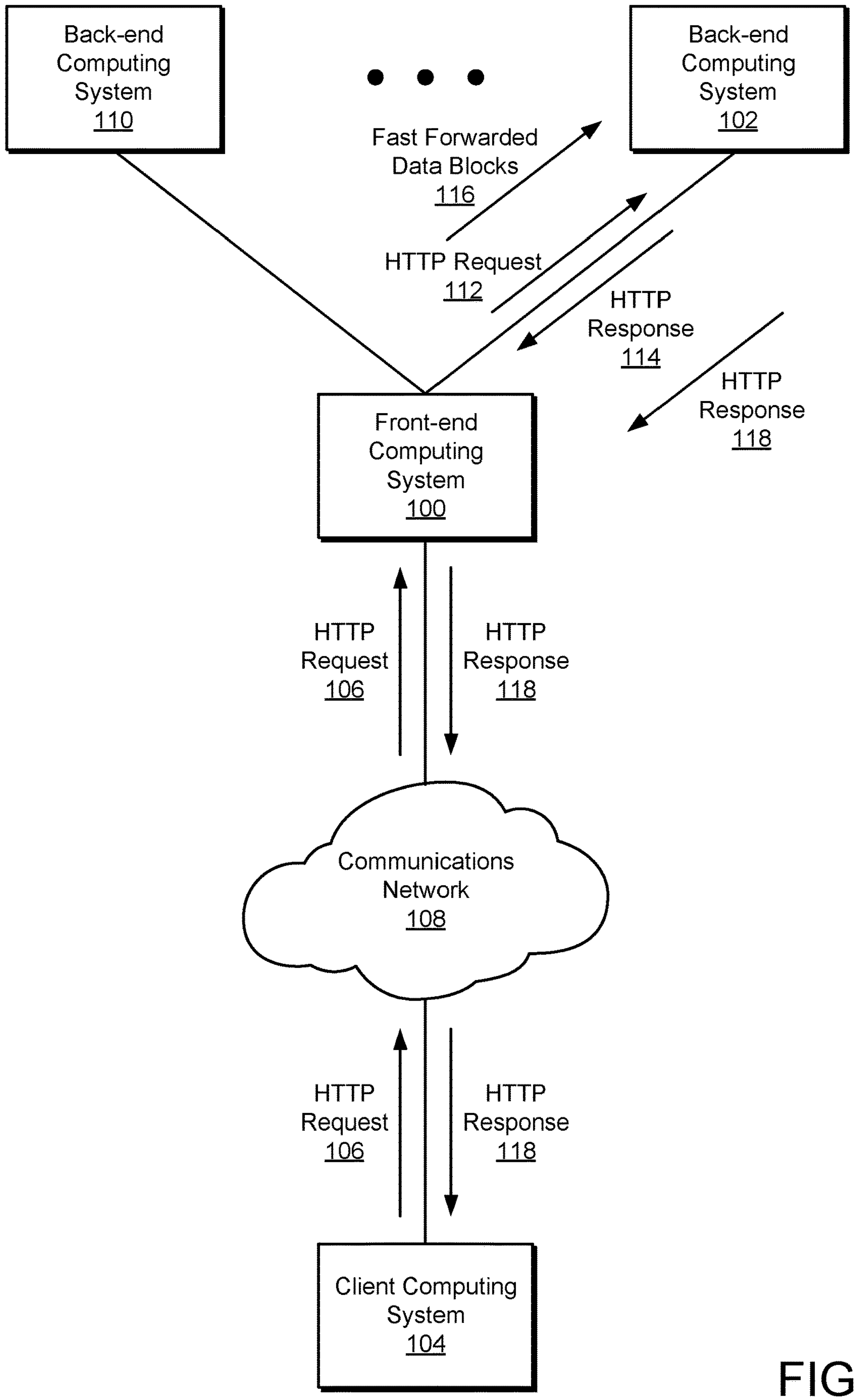

Back-end Computing System 110
Back-end Computing System 102
Fast Forwarded Data Blocks 116
HTTP Request 112
HTTP Response 114
HTTP Response 118
Front-end Computing System 100
HTTP Request 106
HTTP Response 118
Communications Network 108
HTTP Request 106
HTTP Response 118
Client Computing System 104

FIG. 1

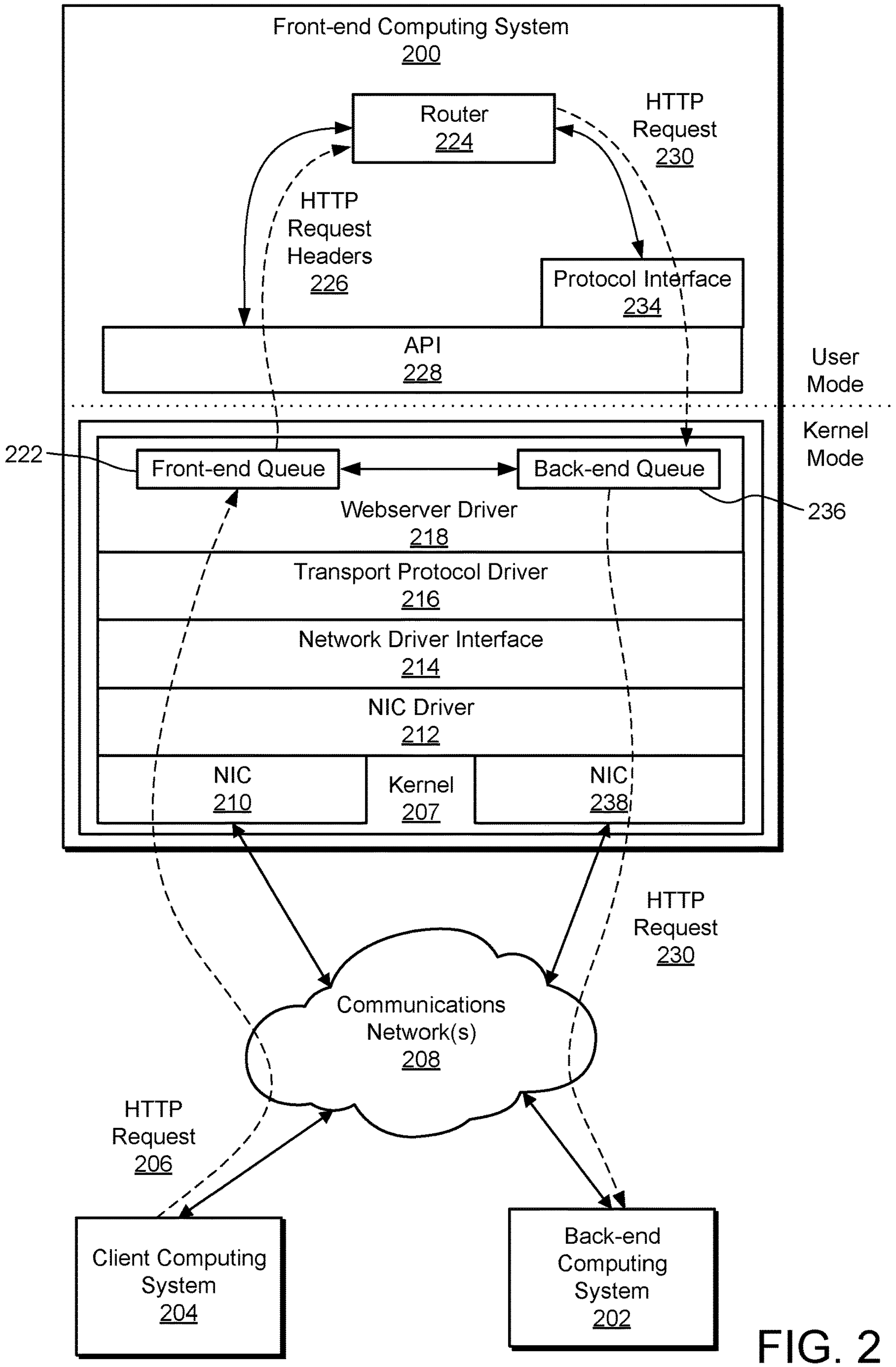

Front-end Computing System
200
Router
224
HTTP
Request
230
HTTP
Request
Headers
226
Protocol Interface
234
API
228
User
Mode
Kernel
Mode
222
Front-end Queue
Back-end Queue
236
Webserver Driver
218
Transport Protocol Driver
216
Network Driver Interface
214
NIC Driver
212
NIC
210
Kernel
207
NIC
238
HTTP
Request
230
Communications
Network(s)
208
HTTP
Request
206
Client Computing
System
204
Back-end
Computing
System
202

FIG. 2

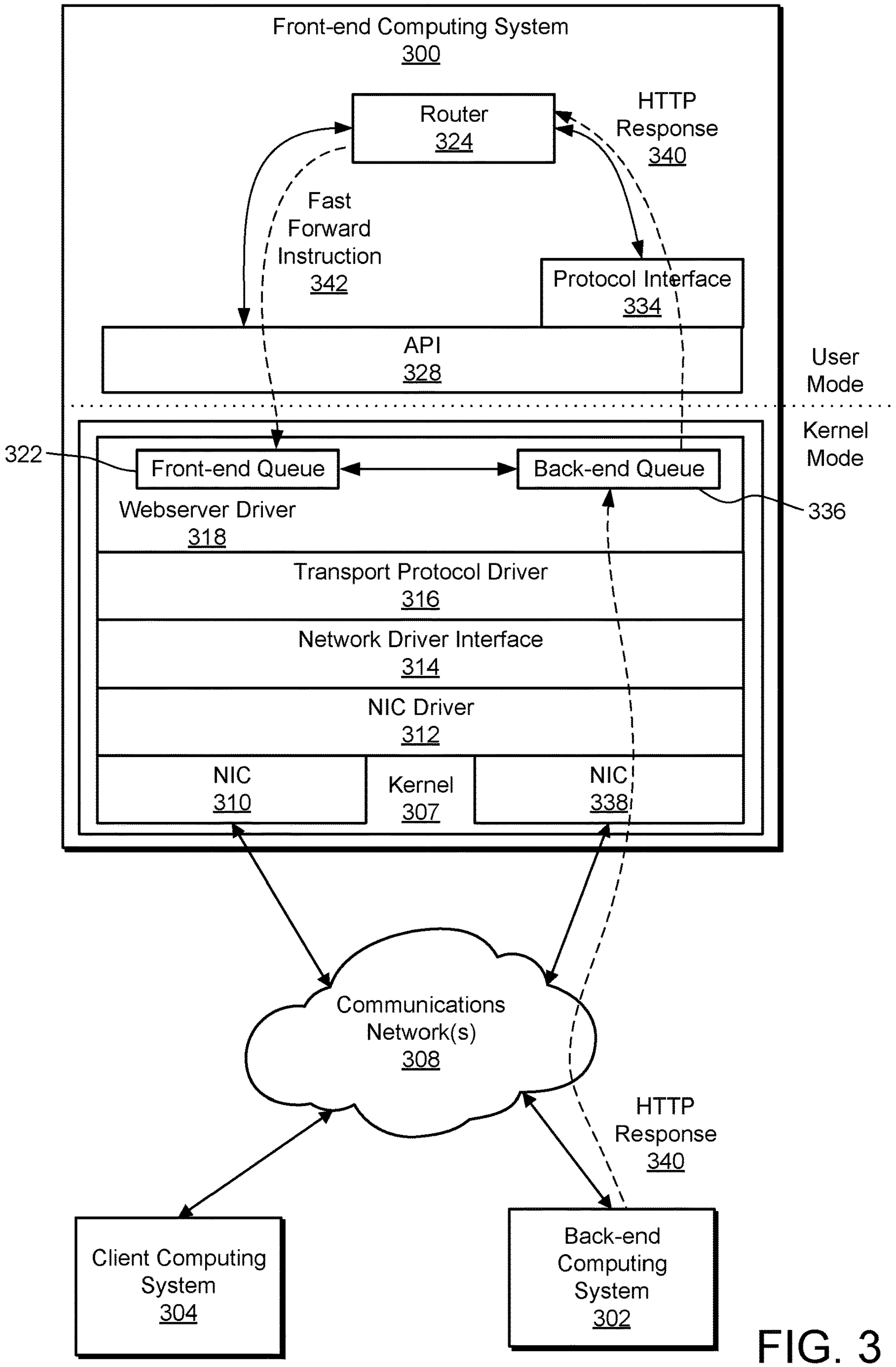

Front-end Computing System
300
Router
324
HTTP Response
340
Fast Forward Instruction
342
Protocol Interface
334
API
328
User Mode
Kernel Mode
322
Front-end Queue
Back-end Queue
336
Webserver Driver
318
Transport Protocol Driver
316
Network Driver Interface
314
NIC Driver
312
NIC
310
Kernel
307
NIC
338
Communications Network(s)
308
HTTP Response
340
Client Computing System
304
Back-end Computing System
302

FIG. 3

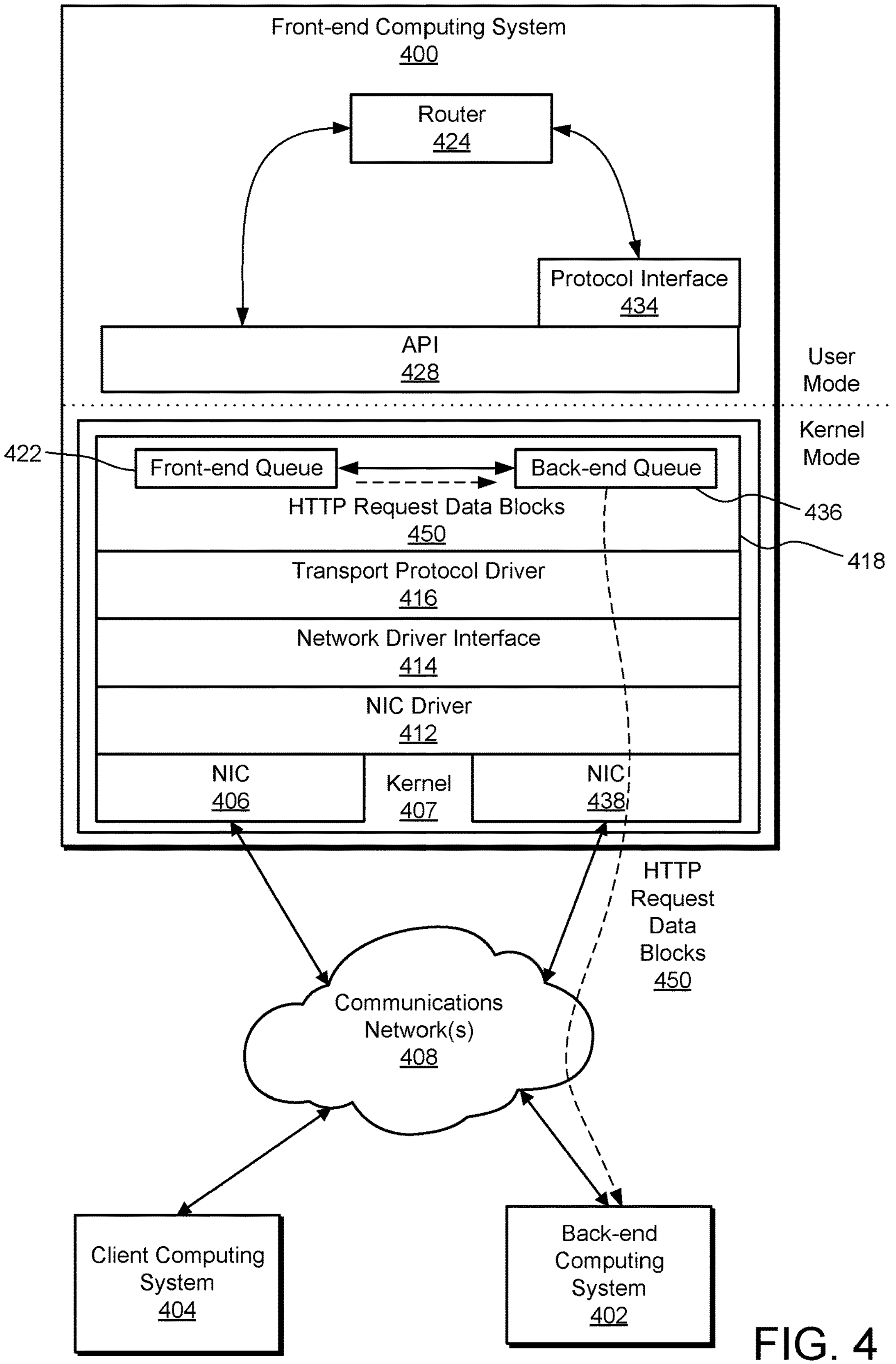

Front-end Computing System
400
Router
424
Protocol Interface
434
API
428
User Mode
Kernel Mode
422
Front-end Queue
Back-end Queue
436
HTTP Request Data Blocks
450
418
Transport Protocol Driver
416
Network Driver Interface
414
NIC Driver
412
NIC
406
Kernel
407
NIC
438
HTTP Request Data Blocks
450
Communications Network(s)
408
Client Computing System
404
Back-end Computing System
402

FIG. 4

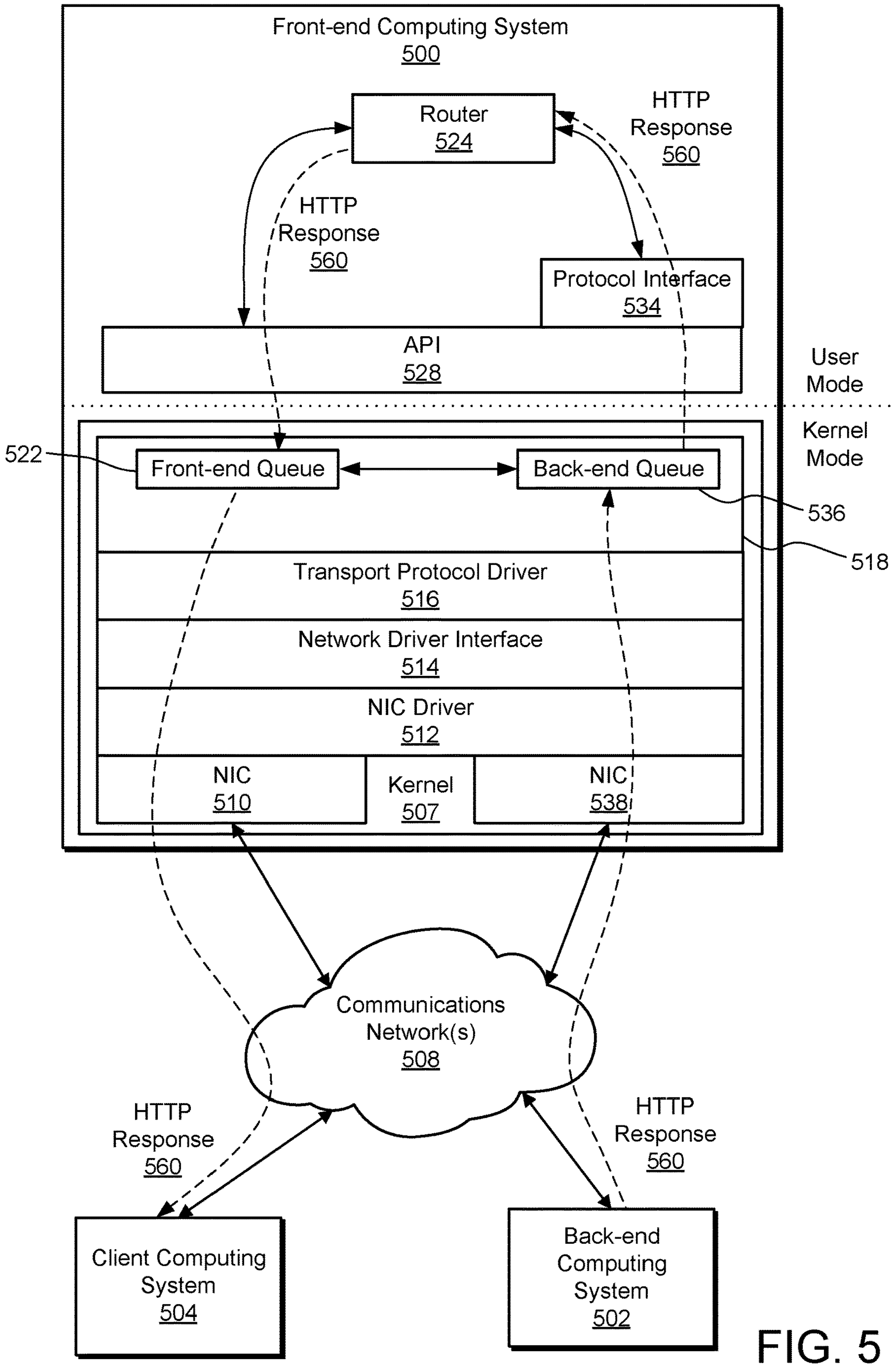

Front-end Computing System
500
Router
524
HTTP Response
560
HTTP Response
560
Protocol Interface
534
API
528
User Mode
Kernel Mode
522
Front-end Queue
Back-end Queue
536
518
Transport Protocol Driver
516
Network Driver Interface
514
NIC Driver
512
NIC
510
Kernel
507
NIC
538
Communications Network(s)
508
HTTP Response
560
HTTP Response
560
Client Computing System
504
Back-end Computing System
502

FIG. 5

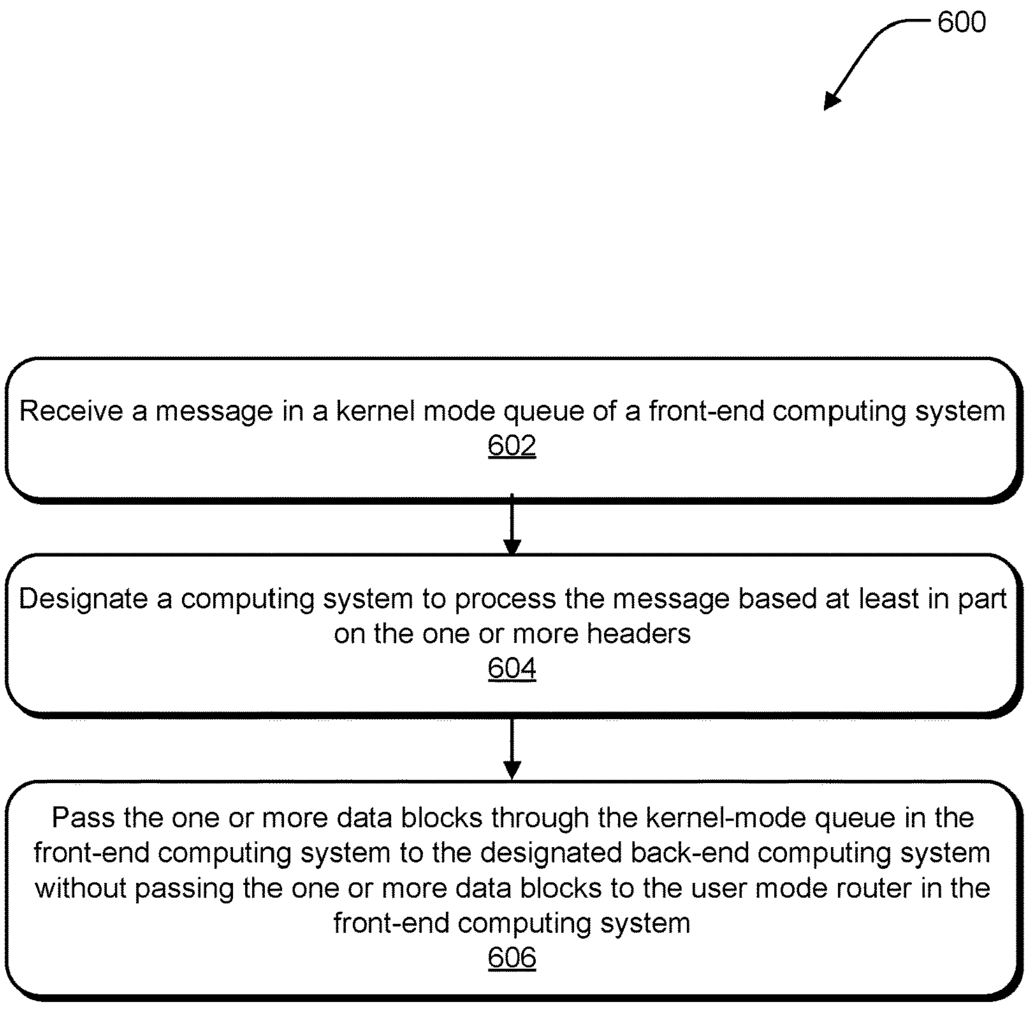

600
Receive a message in a kernel mode queue of a front-end computing system
602
Designate a computing system to process the message based at least in part on the one or more headers
604
Pass the one or more data blocks through the kernel-mode queue in the front-end computing system to the designated back-end computing system without passing the one or more data blocks to the user mode router in the front-end computing system
606

FIG. 6

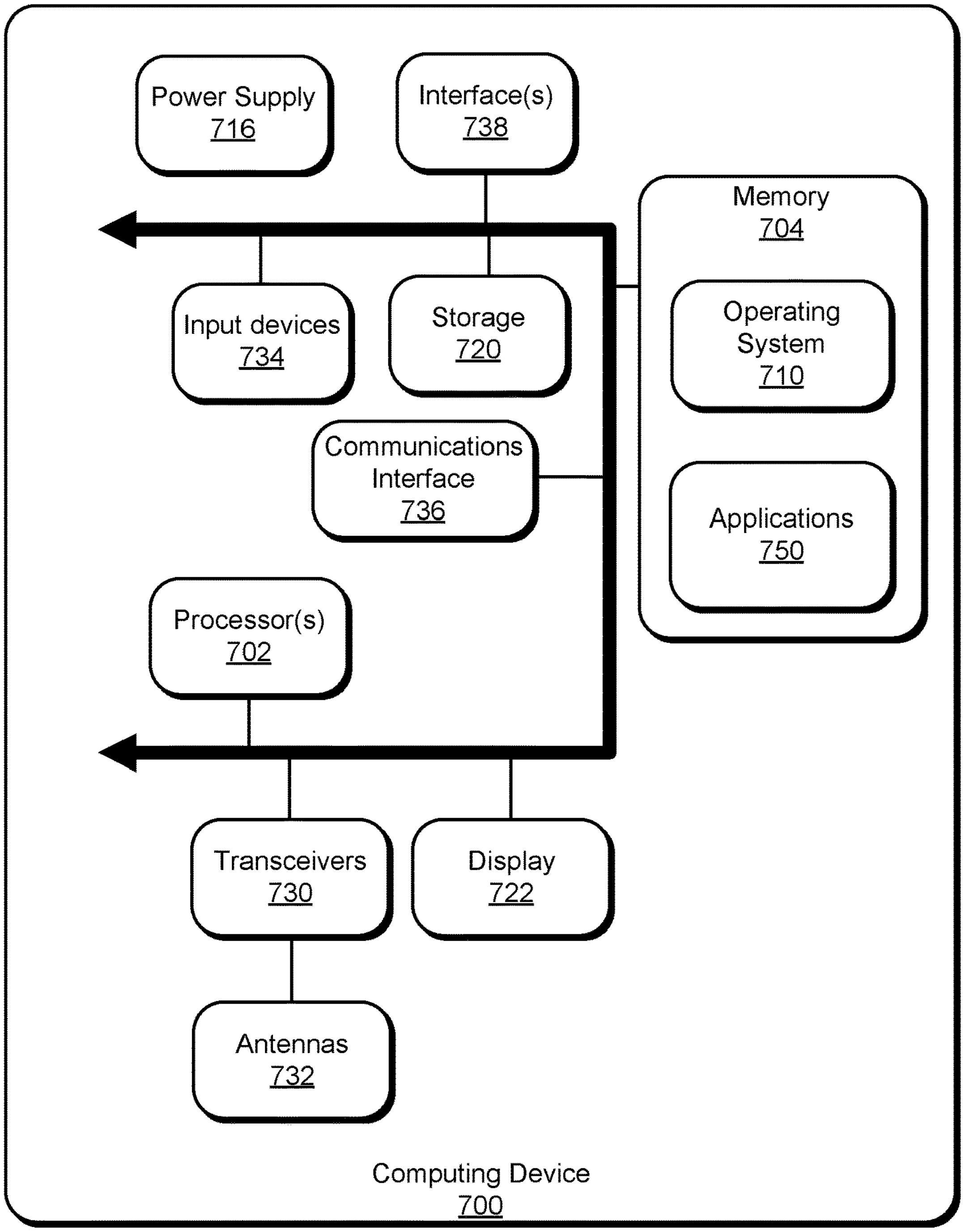

Power Supply
716
Interface(s)
738
Memory
704
Input devices
734
Storage
720
Operating System
710
Communications Interface
736
Applications
750
Processor(s)
702
Transceivers
730
Display
722
Antennas
732
Computing Device
700

FIG. 7

# CROSS MACHINE REQUEST FORWARDING

## BACKGROUND

When executing web services on a webserver, HTTP (HyperText Transfer Protocol) requests are received from a client system by the webserver through a network stack (e.g., a TCP/IP (Transmission Control Protocol/Internet Protocol) stack) executing on the webserver. Responses are generated by the webserver and communicated to the client system, taking a reverse path through the network stack. Generally, requests and responses are referred to as "messages" and may include an entity body. An entity body may be communicated across the network in multiple data blocks according to the network protocol (e.g., if the entity body is too large for a single network packet). In some implementations, the webserver functionality is processed by multiple servers, such as a front-end server and a back-end server.

## SUMMARY

The described technology provides cross machine message forwarding through a front-end computing system. The message is received in a kernel mode queue of the front-end computing system. The message includes one or more headers and an entity body including one or more data blocks. A user mode router in the front-end computing system designates a computing system to process the message based at least in part on the one or more headers. The one or more data blocks are passed through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

This summary is provided to introduce a selection of concepts in a simplified form that is further described below in the Detailed Description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

Other implementations are also described and recited herein.

## BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. **1** illustrates an example front-end computing system supporting fast cross machine request forwarding to a back-end computing system.

FIG. **2** illustrates an example front-end computing system processing a request in support of cross machine request forwarding to a back-end computing system.

FIG. **3** illustrates a router in an example front-end computing system instructing a kernel mode webserver driver to fast forward data blocks of a request to a designated back-end computing system.

FIG. **4** illustrates a kernel mode webserver driver of a front-end computing system fast forwarding data blocks of a request to a designated back-end computing system.

FIG. **5** illustrates an example front-end server computing system processing a response from a back-end computing system after completion of processing a fast forwarded request by the back-end computing system.

FIG. **6** illustrates example operations for forwarding a request through a front-end computing system.

FIG. **7** illustrates exampled hardware and software that can be useful in implementing the described technology.

## DETAILED DESCRIPTIONS

User satisfaction in the web space is tightly correlated with the perception of responsiveness. A study has found that every 100 milliseconds of delay for web services means a 2.4% to 7.1% reduction in conversation rate. Another study found that users are 24% less likely to abandon page loads when sites reduce their delay until being input ready to 100 milliseconds. Accordingly, high latency drives user dissatisfaction with online services, and web services can improve user experience by minimizing latency. Latency is increased by HTTP processing overhead when requests are routed through multiple servers. However, this multi-server routing is often unavoidable in modern deployments. The described technology provides new forwarding mechanisms that will allow online service deployments to intelligently reduce high-latency request processing by front-end servers when forwarding requests to back-end servers.

Multiple-hop request processing (e.g., involving front-end and back-end servers) is becoming more common with the deployment of micro-service architecture. As such, front-end servers are involved with each user request to forward the user requests to appropriate back-end servers for request processing. Multiple-hop request processing can result in increased processing overhead due to multiple passes through HTTP stacks in front-end servers that have nothing to do with the speed of the network pipes connecting the front-end servers. This overhead translates into costs of server space and maintenance that provide little value to the customer or organization.

Fast message forwarding provides functionality for reducing such overhead in front-end servers. For example, when asking Http.sys to move the request to another process queue is impossible, a user mode router process can instruct Http.sys in the kernel to handle moving the data blocks of the request to the back-end server without passing the data blocks to the user mode router process. A similar fast message forwarding process can be executed in the reverse direction when the message is a response. Furthermore, in some implementations, the processing of a request and a corresponding response need not be strictly sequential. In other words, fast forwarding of the data blocks of a request can occur concurrently with the fast forwarding of the data blocks of a corresponding response.

FIG. **1** illustrates an example front-end computing system **100** supporting fast cross machine request forwarding to a back-end computing system **102**. A client computing system **104** transmits a request, such as an HTTP request **106**, through a communications network **108** to the front-end computing system **100**. An HTTP request can include one or more headers and, optionally, an entity body (which can be made up of one or more data blocks communicated over the network). Generally, HTTP request headers can include a general header, a client request header, and/or an entity header (i.e., a header field defining metainformation about the entity body, if any), and HTTP response headers may include a general header, a server response header, and/or an entity header. The HTTP request **106** is received in a front-end queue of a kernel mode webserver driver (e.g., http.sys) of the front-end computing system **100**.

It should be understood that much of this description is based on the fast forwarding of data blocks associated with a request. Nevertheless, fast forwarding can also be applied to data blocks associates with a response, the details of which are the same as those relating to the request flow.

Typically, the front-end computing system **100** is communicatively coupled to multiple back-end computing systems (e.g., the back-end computing system **102** and a back-end computing system **110**), and a user-mode router process in the front-end computing system designates one of the back-end computing systems to process the HTTP request **106**. In one implementation, the router process designates the appropriate back-end computing system by extracting one or more headers from the HTTP request **106**, creating a new HTTP request **112** with the one or more headers, and sending the new HTTP request **112** to one of the back-end computing systems. If the corresponding back-end computing system can process the HTTP request **106**, based on the header information in the new HTTP request **112**, the back-end computing system **102** will respond with an HTTP response **114** indicating its acceptance. If the back-end computing system **102** cannot process the HTTP request **106**, it will indicate its non-acceptance in the HTTP response **114**, and the front-end computing system **100** will check with other back-end computing systems until a viable processing system is found.

The front-end computing system **100** processes the HTTP response **114** to confirm acceptance by the back-end computing system **102** and then instructs a kernel mode webserver driver to fast forward the data blocks **116** of entity body of the HTTP request **106** through kernel mode in the front-end computing system **100** to the back-end computing system **102**, without passing the data blocks **116** through the user mode of the front-end computing system **100**. In one implementation, the data blocks are transmitted as a sequence of data packets to the back-end computing system **102**. In this manner, the data packets (e.g., IP data packets) of the data blocks **116** are forwarded without the overhead of passage through user mode or the generation of separate HTTP requests in user mode.

After processing the data blocks **116** of the HTTP request **106**, the back-end computing system **102** generates an HTTP response **118**, acknowledging completion of the request and/or returning results of the processing. The front-end computing system **100** passes the HTTP response **118** (or its own version of the response) to the client computing system **104**. It should be understood that the response from the back-end computing system **102** may itself include an entity body of one or more data blocks, which the router process of the front-end computing system **100** may send to the client computing system **104** using fast forwarding through the kernel mode.

In an implementation (not shown), the front-end computing system **100** can also (or alternatively) execute a fast forwarding process on the HTTP response **118**, in a similar manner as performed on the HTTP request **106**. In this implementation, the front-end computing system **100** instructs its kernel mode webserver driver to fast forward the data blocks of an entity body of the HTTP response **118** through kernel mode in the front-end computing system **100** to the client computing system **104** without passing the data blocks through the user mode of the front-end computing system **100**. Accordingly, similar overhead reductions can be achieved in the response flow as well.

FIGS. **2-5** illustrate sequential stages of an example fast forwarding flow for a request from a client. FIG. **2** illustrates an example stage of a front-end computing system sending one or more headers of a request to a candidate back-end computing system (e.g., to determine whether the candidate back-end computing system will accept the responsibility of processing the request from the client). FIG. **3** illustrates an example stage of a front-end computing system receiving a response from a candidate back-end computing system indicating acceptance of the responsibility of processing the request from the client and then instructing a webserver driver to fast forward one or more data blocks of the entity body of a request through kernel mode without passing through user mode of the front-end computing system. FIG. **4** illustrates an example stage of a front-end computing system fast forwarding one or more data blocks of the entity body of a request through kernel mode to a back-end computing system without passing through user mode of the front-end computing system. FIG. **5** illustrates an example stage of a front-end computing system forwarding a response from a back-end computing system (which processed an original request) to the client computing system that initiated the original request. It should be understood that the response from the back-end computing system may also include an entity body, and the front-end computing system may also apply fast forwarding to the data blocks of the entity body of the response. Furthermore, in some implementation, the stages need not be strictly sequential, in that the processing of the request and the corresponding response may overlap to some extent, whether either direction of the respective processing employs fast forwarding or not.

FIG. **2** illustrates an example front-end computing system **200** processing a request in support of cross machine request forwarding to a back-end computing system **202**. A client computing system **204** transmits an HTTP request **206** through a communications network **208** to the front-end computing system **200**. The front-end computing system **200** receives the HTTP request via the communications network **208** and a network interface **210** (e.g., a "NIC" or "network interface card") of the webserver **200**. The requests and responses are communicated through a network stack in the kernel **207** of the operating system of the front-end computing system **200**.

In the illustrated implementation, the network stack includes multiple hardware and software layers, including the network interface **210**, a NIC driver **212**, a network driver interface **214** (e.g., ndis.sys), and a transport protocol driver **216** (e.g., a TCP/IP protocol driver, such as tcpip.sys). Nevertheless, it should be understood that other network stack configurations are contemplated for other implementations of the described technology. A webserver driver **218** manages the front-end queue **222** and the back-end queue **236**. For example, http.sys is an HTTP protocol driver running as a kernel mode webserver driver between a TCP/IP protocol driver and the user mode router and service processes (e.g., a web service processes, HTTP service process).

The HTTP request **206** is received by the front-end computing system **200** in a front-end queue **222**. A router process ("router **224**") in the user mode can extract the HTTP request headers **226** of the HTTP request **206** through an API **228** (Application Programming Interface). The router **224** generates an HTTP request **230** based on HTTP request headers **226** and sends it to a back-end computing system **202** through a protocol driver **234**, the API **228**, a back-end queue **236** in the webserver driver **218**, and another NIC **238**. The back-end computing system **202** evaluates the HTTP request **230** to determine whether it can process the HTTP request **206**.

It should be understood that, in the illustrated implementation, a unified network stack in kernel mode (e.g., including the NIC driver **212**, the network driver interface **214**, the transport protocol driver **216**, and the webserver driver **218**) is used in fast forwarding data blocks of an entity body in message (request or response) flow. Accordingly, for fast forwarding in either direction, the one or more data blocks of an entity body may flow exclusively through the network stack in kernel without flowing through user mode network stack components, thus reducing unnecessary latency.

In some implementations, the front-end computing system **200** need not employ multiple NICs. Furthermore, in some implementations, one or more NICs may communicate across different networks (e.g., the public Internet and a private back-end network of a datacenter). The implementation variations also apply to the examples of FIG. **3**-**5**.

FIG. **3** illustrates a router **324** in an example front-end computing system **300** instructing a kernel mode webserver driver **318** to fast forward data blocks of a request to a designated back-end computing system **302**. In the illustrated part of the processing flow, the back-end computing system **302** has received an HTTP request with the header information of an HTTP request received from a client computing system **304**. The back-end computing system **302** responds to indicate whether it can process the HTTP request from the client computing system **304**. In either case, the back-end computing system **302** generates an HTTP response **340** and sends it to the front-end computing system **300**, indicating the result of this determination.

The HTTP response **340** is received by the front-end computing system **300** in a back-end queue **336** through a network stack. In the illustrated implementation, the network stack includes multiple hardware and software layers, including the NIC **338**, a NIC driver **312**, a network driver interface **314** (e.g., ndis.sys), and a transport protocol driver **316** (e.g., a TCP/IP protocol driver, such as tcpip.sys). Nevertheless, it should be understood that other network stack configurations are contemplated for other implementations of the described technology. Note that a separate NIC **310** may be used to connect the front-end computing system **300** to the communications network **308** and the client computing system **304**.

A webserver driver **318** manages a front-end queue **322** and the back-end queue **336**. For example, http.sys is an HTTP protocol driver running as a kernel mode webserver driver between a TCP/IP protocol driver and the user mode router and service processes (e.g., a web service processes, HTTP service process). The HTTP response **340** is passed through the back-end queue **336**, an API **328**, and a protocol interface **334** to a router **324**. If the back-end computing system **302** declines to process the HTTP request, the router **324** of the front-end computing system **300** can request that another back-end computing system process the client's request. Otherwise, the router **324** of the front-end computing system **300** instructs web server driver **318** to forward the data blocks of the client's HTTP request through the kernel **307** to the designated back-end computing system **302** without passing the data blocks to the user mode.

FIG. **4** illustrates a kernel mode web server driver **418** of a front-end computing system **400** fast forwarding data blocks of a request to a designated back-end computing system **402**. In the illustrated part of the processing flow, the back-end computing system **402** has indicated acceptance of the front-end computing system's request to process the client's HTTP request, and a router **424** front-end computing system **400** has instructed a webserver driver **418** to fast forward the data blocks of the client's HTTP request to the back-end computing system **402**. Accordingly, the HTTP request data blocks **450** are forwarded in the kernel **407** from the front-end queue **422** to the back-end queue **436** and then out through the network stack to the back-end computing system **402** for processing.

In the illustrated implementation, the network stack includes multiple hardware and software layers, including

the NIC **438**, a NIC driver **412**, a network driver interface **414** (e.g., ndis.sys), and a transport protocol driver **416** (e.g., a TCP/IP protocol driver, such as tcpip.sys). Nevertheless, it should be understood that other network stack configurations are contemplated for other implementations of the described technology. Note that a separate NIC **410** may be used to connect the front-end computing system **400** to the communications network **408** and the client computing system **404**.

FIG. **5** illustrates an example front-end server computing system **500** processing a response from a back-end computing system **502** after completion of processing a fast forwarded request by the back-end computing system **502**. The back-end computing system **502** generates an HTTP response **560** (e.g., acknowledging receipt of the client's request and/or providing a result of the requested processing) and transmits the HTTP response **560** through the communications network **508** and the network stack of the front-end computing system **500**.

In the illustrated implementation, the network stack includes multiple hardware and software layers, including the NIC **538**, a NIC driver **512**, a network driver interface **514** (e.g., ndis.sys), and a transport protocol driver **516** (e.g., a TCP/IP protocol driver, such as tcpip.sys). Nevertheless, it should be understood that other network stack configurations are contemplated for other implementations of the described technology. Note that a separate NIC **510** may be used to connect the front-end computing system **500** to the communications network **508** and the client computing system **504**. The HTTP response **560** is received in the back-end queue **536**, extracted from the back-end queue **536** by the router **524** through the API **528** and the protocol interface **534**, and forwarded through the front-end queue **522** in the network stack to a client computing system **504**.

It should be understood that the front-end computing system **500** can also implement a similar fast forwarding process for the HTTP response **560**, such that the data blocks of the HTTP response **560** are not passed through the user mode components of the standard message flow. Also, in some implementations, the fast forwarding of request and (corresponding) response data blocks can be performed concurrently.

FIG. **6** illustrates example operations **600** for forwarding a request through a front-end computing system. A receiving operation receives a message (e.g., an HTTP request or an HTTP response) in a kernel mode queue of a front-end computing system. The message includes one or more headers and one or more data blocks. A routing operation **604** designates a computing system (e.g., a back-end computing system if the message is an HTTP request or a client computing system if the message is an HTTP response) to process the message based at least in part on the one or more headers of the message. A communications operation **506** passes the one or more data blocks through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

FIG. **7** illustrates an example computing device **700** for implementing the features and operations of the described technology. The computing device **700** may embody a remote control device or a physical controlled device and is an example network-connected and/or network-capable device and may be a client device, such as a laptop, mobile device, desktop, tablet; a server/cloud device; an internet-of-things device; an electronic accessory; or another electronic device. The computing device **700** includes one or more processor(s) **702** and a memory **704**. The memory **704** generally includes both volatile memory (e.g., RAM) and nonvolatile memory (e.g., flash memory). An operating system **710** resides in the memory **704** and is executed by the processor(s) **702**.

In an example computing device **700**, as shown in FIG. **7**, one or more modules or segments, such as applications **750**, a router process, a webserver driver, a network stack component, and other services, workloads, and modules, are loaded into the operating system **710** on the memory **704** and/or storage **720** and executed by processor(s) **702**. The storage **720** may include one or more tangible storage media devices and may store locally and globally unique identifiers, requests, responses, headers, data blocks, and other data and be local to the computing device **700** or may be remote and communicatively connected to the computing device **700**.

The computing device **700** includes a power supply **716**, which is powered by one or more batteries or other power sources and which provides power to other components of the computing device **700**. The power supply **716** may also be connected to an external power source that overrides or recharges the built-in batteries or other power sources.

The computing device **700** may include one or more communication transceivers **730**, which may be connected to one or more antenna(s) **732** to provide network connectivity (e.g., mobile phone network, Wi-Fi®, Bluetooth®) to one or more other servers and/or client devices (e.g., mobile devices, desktop computers, or laptop computers). The computing device **700** may further include a network adapter **736**, which is a type of computing device. The computing device **700** may use the adapter and any other types of computing devices for establishing connections over a wide-area network (WAN) or local-area network (LAN). It should be appreciated that the network connections shown are exemplary and that other computing devices and means for establishing a communications link between the computing device **700** and other devices may be used.

The computing device **700** may include one or more input devices **734** such that a user may enter commands and information (e.g., a keyboard or mouse). These and other input devices may be coupled to the server by one or more interfaces **738**, such as a serial port interface, parallel port, or universal serial bus (USB). The computing device **700** may further include a display **722**, such as a touch screen display.

The computing device **700** may include a variety of tangible processor-readable storage media and intangible processor-readable communication signals. Tangible processor-readable storage can be embodied by any available media that can be accessed by the computing device **700** and includes both volatile and nonvolatile storage media, removable and non-removable storage media. Tangible processor-readable storage media excludes communications signals (e.g., signals per se) and includes volatile and nonvolatile, removable and non-removable storage media implemented in any method or technology for storage of information such as processor-readable instructions, data structures, program modules, or other data. Tangible processor-readable storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CDROM, digital versatile disks (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other tangible medium which can be used to store the desired information and which can be accessed by the computing device **700**. In contrast to tangible processor-readable storage media, intangible processor-readable communication signals may embody processor-readable instructions, data structures, program modules, or other data resident in a modulated data signal, such as a carrier wave or other signal transport mechanism. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, intangible communication signals include signals traveling through wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared, and other wireless media.

Various software components described herein are executable by one or more processors, which may include logic machines configured to execute hardware or firmware instructions. For example, the processors may be configured to execute instructions that are part of one or more applications, services, programs, routines, libraries, objects, components, data structures, or other logical constructs. Such instructions may be implemented to perform a task, implement a data type, transform the state of one or more components, achieve a technical effect, or otherwise arrive at a desired result.

Aspects of processors and storage may be integrated together into one or more hardware logic components. Such hardware-logic components may include field-programmable gate arrays (FPGAs), program- and application-specific integrated circuits (PASIC/ASICs), program- and application-specific standard products (PSSP/ASSPs), system-on-a-chip (SOC), and complex programmable logic devices (CPLDs), for example.

The terms "module," "program," and "engine" may be used to describe an aspect of a remote control device and/or a physical controlled device **802** implemented to perform a particular function. It will be understood that different modules, programs, and/or engines may be instantiated from the same application, service, code block, object, library, routine, API, function, etc. Likewise, the same module, program, and/or engine may be instantiated by different applications, services, code blocks, objects, routines, APIs, functions, etc. The terms "module," "program," and "engine" may encompass individual or groups of executable files, data files, libraries, drivers, scripts, database records, etc.

It will be appreciated that a "service," as used herein, is an application program executable across one or multiple user sessions. A service may be available to one or more system components, programs, and/or other services. In some implementations, a service may run on one or more server computing devices.

An example method of forwarding a message through a front-end computing system includes receiving the message in a kernel mode queue of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks; designating, by a user mode router in the front-end computing system, a computing system to process the message based at least in part on the one or more headers; and passing the one or more data blocks through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

Another method of any preceding method is provided, wherein the designating operation includes extracting the one or more headers from the message to the user mode router in the front-end computing system; routing a request including the one or more headers from the front-end computing system to the designated computing system, the request requesting the designated computing system to process the message; and receiving a response to the request from the designated computing system at the front-end computing system, based at least in part on the response indicating to the front-end computing system that the designated computing system can process the message.

Another method of any preceding method is provided, wherein the message is a request, and the designated computing system is a back-end computing system designated to process the request.

Another method of any preceding method is provided, wherein the message is a response, and the designated computing system is a client computing system designated to process the response.

Another method of any preceding method is provided, wherein the one or more data blocks of the message are passed between a front-end queue and a back-end queue within a kernel mode webserver driver of the front-end computing system.

Another method of any preceding method is provided, wherein the message is received by the front-end computing system as a request from a client computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks are transmitted to the designated computing system via the unified network stack of the front-end computing system.

Another method of any preceding method is provided, wherein the message is received by the front-end computing system as a response from a back-end computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks transmitted to the designated computing system via the unified network stack of the front-end computing system.

An example front-end computing system for forwarding a message through the front-end computing system includes one or more hardware processors; memory; a kernel mode queue in the memory of the front-end computing system, the message being received in the kernel mode queue of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks; a user mode router in the front-end computing system, the user mode router being executable by the one or more hardware processors and configured to designate a computing system to process the message based at least in part on the one or more headers; and a kernel mode webserver driver executable by the one or more hardware processors and configured to pass the one or more data blocks through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

Another example front-end computing system of any preceding system is provided, wherein the user mode router is further configured to extract the one or more headers from the message to the user mode router in the front-end computing system; route a request including the one or more headers from the front-end computing system to the designated computing system, the request requesting the designated computing system to process the message; and receive a response to the request from the designated computing system at the front-end computing system, based at least in part on the response indicating to the front-end computing system that the designated computing system can process the message.

Another example front-end computing system of any preceding system is provided, wherein the message is a request, and the designated computing system is a back-end computing system designated to process the request.

Another example front-end computing system of any preceding system is provided, wherein the message is a response, and the designated computing system is a client computing system designated to process the response.

Another example front-end computing system of any preceding system is provided, wherein the one or more data blocks of the message are passed between a front-end queue and a back-end queue within the kernel mode webserver driver of the front-end computing system.

Another example front-end computing system of any preceding system is provided, wherein the message is received by the front-end computing system as a request from a client computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks are transmitted to the designated computing system via the unified network stack of the front-end computing system.

Another example front-end computing system of any preceding system is provided, wherein the message is received by the front-end computing system as a response from a back-end computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks transmitted to the designated computing system via the unified network stack of the front-end computing system.

One or more example tangible processor-readable storage media of a tangible article of manufacture encoding processor-executable instructions for executing a computing process on a front-end computing system for forwarding a message through the front-end computing system is provided. The computing process includes receiving the message in a kernel mode queue of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks; designating, by a user mode router in the front-end computing system, a computing system to process the message based at least in part on the one or more headers; and passing the one or more data blocks through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

Other one or more example tangible processor-readable storage media of any preceding media are provided, wherein the designating operation includes extracting the one or more headers from the message to the user mode router in the front-end computing system; routing a request including the one or more headers from the front-end computing system to the designated computing system, the request requesting the designated computing system to process the message; and receiving a response to the request from the designated computing system at the front-end computing system, based at least in part on the response indicating to the front-end computing system that the designated computing system can process the message.

Other one or more example tangible processor-readable storage media of any preceding media are provided, wherein the message is a request, and the designated computing system is a back-end computing system designated to process the request.

Other one or more example tangible processor-readable storage media of any preceding media are provided, wherein the one or more data blocks of the message are passed between a front-end queue and a back-end queue within a kernel mode web server driver of the front-end computing system.

Other one or more example tangible processor-readable storage media of any preceding media are provided, wherein the message is received by the front-end computing system as a request from a client computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks are transmitted to the designated computing system via the unified network stack of the front-end computing system.

Other one or more example tangible processor-readable storage media of any preceding media are provided, wherein the message is received by the front-end computing system as a response from a back-end computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks transmitted to the designated computing system via the unified network stack of the front-end computing system.

Another example system of forwarding a message through a front-end computing system includes means for receiving the message in a kernel mode queue of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks; means for designating, by a user mode router in the front-end computing system, a computing system to process the message based at least in part on the one or more headers; and means for passing the one or more data blocks through the kernel mode queue in the front-end computing system to the designated computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

Another system of any preceding system is provided, wherein the means for designating includes means for extracting the one or more headers from the message to the user mode router in the front-end computing system; means for routing a request including the one or more headers from the front-end computing system to the designated computing system, the request requesting the designated computing system to process the message; and means for receiving a response to the request from the designated computing system at the front-end computing system, based at least in part on the response indicating to the front-end computing system that the designated computing system can process the message.

Another system of any preceding system is provided, wherein the message is a request, and the designated computing system is a back-end computing system designated to process the request.

Another system of any preceding system is system, wherein the message is a response, and the designated computing system is a client computing system designated to process the response.

Another system of any preceding system is provided, wherein the one or more data blocks of the message are passed between a front-end queue and a back-end queue within a kernel mode webserver driver of the front-end computing system.

Another system of any preceding system is provided, wherein the message is received by the front-end computing system as a request from a client computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks are transmitted to the designated computing system via the unified network stack of the front-end computing system.

Another system of any preceding method is system, wherein the message is received by the front-end computing system as a response from a back-end computing system via a unified network stack in kernel mode of the front-end computing system and the one or more data blocks transmitted to the designated computing system via the unified network stack of the front-end computing system.

While this specification contains many specific implementation details, these should not be construed as limitations on the scope of any inventions or of what may be claimed, but rather as descriptions of features specific to particular embodiments of a particular described technology. Certain features that are described in this specification in the context of separate embodiments can also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment can also be implemented in multiple embodiments separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a subcombination or variation of a sub combination.

Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the embodiments described above should not be understood as requiring such separation in all embodiments, and it should be understood that the described program components and systems can generally be integrated together in a single software product or packaged into multiple software products.

Thus, particular embodiments of the subject matter have been described. Other embodiments are within the scope of the following claims. In some cases, the actions recited in the claims can be performed in a different order and still achieve desirable results. In addition, the processes depicted in the accompanying figures do not necessarily require the particular order shown, or sequential order, to achieve desirable results. In certain implementations, multitasking and parallel processing may be advantageous.

A number of implementations of the described technology have been described. Nevertheless, it will be understood that various modifications can be made without departing from the spirit and scope of the recited claims.

What is claimed is:

**1**. A method of forwarding a message through a front-end computing system, the method comprising:

- receiving the message in a kernel mode of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks;
- designating, by a user mode router in the front-end computing system, a computing system to process the message based at least in part on the one or more headers;
- generating a request for processing the message based at least in part on the one or more headers;
- sending the request to the computing system;
- receiving a response informing the front-end computing system whether the computing system can process the message;
- based on the response informing the front-end computing system that the computing system can process the message;
- forwarding the one or more data blocks of the message from a front-end queue within a kernel mode webserver

driver of the front-end computing system to a back-end queue within the kernel mode webserver driver of the front-end computing system; and

passing the one or more data blocks from the back-end queue within the kernel mode webserver driver of the front-end computing system to the computing system without passing the one or more data blocks to the user mode router in the front-end computing system; and

based on the response informing the front-end computing system that the computing system cannot process the message, requesting another computing system to process the message.

**2**. The method of claim **1**, wherein the message is associated with another request, and the computing system is a back-end computing system designated to process the other request.

**3**. The method of claim **1**, wherein the message is received by the front-end computing system as another request from a client computing system via a unified network stack in the kernel mode of the front-end computing system and the one or more data blocks are transmitted to the computing system via the unified network stack of the front-end computing system.

**4**. A front-end computing system comprising:

one or more hardware processors; and

one or more tangible processor-readable storage media of a tangible article of manufacture encoding processor-executable instructions for executing operations on the front-end computing system for forwarding a message, the operations comprising:

receiving the message in a kernel mode of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks;

designating, by a user mode router in the front-end computing system, a computing system to process the message based at least in part on the one or more headers;

forwarding the one or more data blocks of the message from a front-end queue within a kernel mode webserver driver of the front-end computing system to a back-end queue within the kernel mode webserver driver of the front-end computing system; and

passing the one or more data blocks in the back-end queue within the kernel mode webserver driver of the front-end computing system to the computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

**5**. The front-end computing system of claim **4**, wherein the designating comprises:

extracting the one or more headers from the message to the user mode router in the front-end computing system;

routing a request including the one or more headers from the front-end computing system to the computing system, the request requesting the computing system to process the message; and

receiving a response to the request from the computing system at the front-end computing system, the response indicating to the front-end computing system that the computing system can process the message.

**6**. The front-end computing system of claim **4**, wherein the message is a request, and the computing system is a back-end computing system designated to process the request.

**7**. The front-end computing system of claim **4**, wherein the message is received by the front-end computing system as a request from a client computing system via a unified network stack in the kernel mode of the front-end computing system and the one or more data blocks are transmitted to the computing system via the unified network stack of the front-end computing system.

**8**. A method of forwarding a message through a front-end computing system, the method comprising:

receiving the message in a kernel mode of the front-end computing system, the message including one or more headers and an entity body including one or more data blocks;

designating, by a user mode router in the front-end computing system, a computing system to process the message based at least in part on the one or more headers;

forwarding the one or more data blocks of the message from a front-end queue within a kernel mode webserver driver of the front-end computing system to a back-end queue within the kernel mode webserver driver of the front-end computing system; and

passing the one or more data blocks in the back-end queue within the kernel mode webserver driver of the front-end computing system to the computing system without passing the one or more data blocks to the user mode router in the front-end computing system.

**9**. The method of claim **8**, further comprising:

extracting the one or more headers from the message to the user mode router in the front-end computing system;

routing a request including the one or more headers from the front-end computing system to the computing system, the request requesting the computing system to process the message; and

receiving a response to the request from the computing system at the front-end computing system, the response indicating to the front-end computing system that the computing system can process the message.

**10**. The method of claim **8**, wherein the message is a request, and the computing system is a back-end computing system designated to process the request.

**11**. The method of claim **8**, wherein the message is received by the front-end computing system as a request from a client computing system via a unified network stack in the kernel mode of the front-end computing system and the one or more data blocks are transmitted to the computing system via the unified network stack of the front-end computing system.

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