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Haynie et al.

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(54) **METHOD, SYSTEM, AND COMPUTER PROGRAM PRODUCT FOR ETHERNET VIRTUALIZATION USING AN ELASTIC FIFO MEMORY TO FACILITATE FLOW OF UNKNOWN TRAFFIC TO VIRTUAL HOSTS**

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This patent is subject to a terminal disclaimer.

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G06F 11/00 (2006.01)

(52) **U.S. Cl.** **370/392**; 370/248; 370/401; 711/203; 709/238

(58) **Field of Classification Search** 370/230–232, 370/248–422; 711/4, 114, 203; 709/220, 709/238; 700/2
See application file for complete search history.

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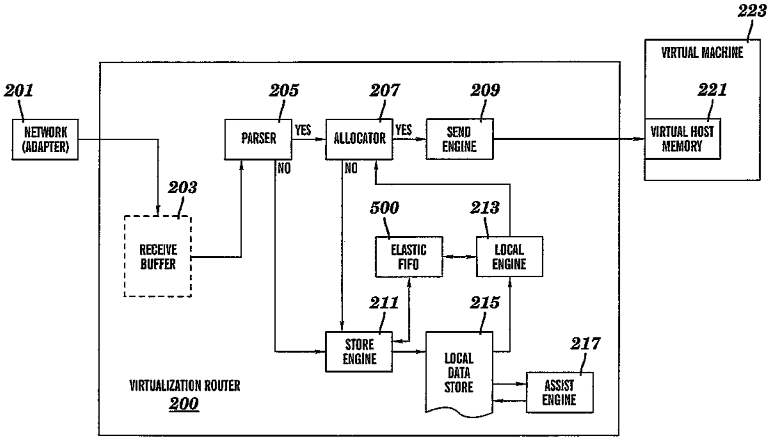
(57) **ABSTRACT**

A packet that represents unknown traffic for a virtual host is received. A first test is performed to ascertain whether or not a destination connection can be determined for the received packet wherein, if a destination connection can be determined, a second test is performed to ascertain whether or not one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection are available. If a destination connection for the packet cannot be determined, the packet is passed to a store engine. If the one or more connection-specific resources are not available, the packet is passed to the store engine. The store engine obtains a free packet buffer from a FIFO memory. The store engine moves the packet into the free packet buffer and submits the free packet buffer to the elastic FIFO memory. A monitoring procedure is performed to detect both an availability of connection-specific resources and a presence of one or more waiting packets with a known destination connection. When (i) a destination connection with one or more waiting packets, and (ii) available connection-specific resources, are both detected, removing the packet from the local data store; allocating the one or more connection-specific resources required to send the packet to the virtual host memory corresponding to the connection destination; and writing the packet to the virtual host memory.

21 Claims, 6 Drawing Sheets



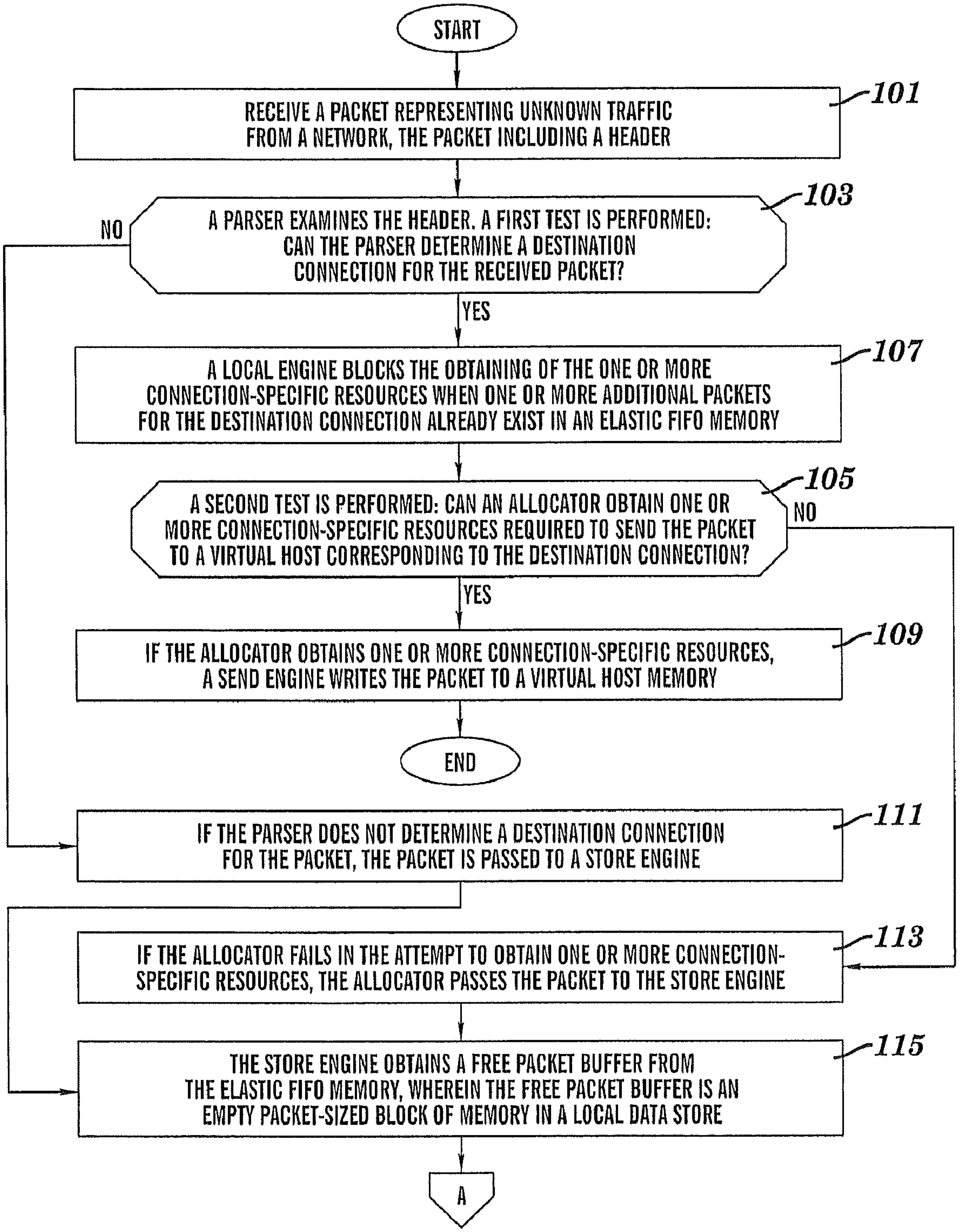

START
RECEIVE A PACKET REPRESENTING UNKNOWN TRAFFIC FROM A NETWORK, THE PACKET INCLUDING A HEADER
101
A PARSER EXAMINES THE HEADER. A FIRST TEST IS PERFORMED: CAN THE PARSER DETERMINE A DESTINATION CONNECTION FOR THE RECEIVED PACKET?
103
NO
YES
A LOCAL ENGINE BLOCKS THE OBTAINING OF THE ONE OR MORE CONNECTION-SPECIFIC RESOURCES WHEN ONE OR MORE ADDITIONAL PACKETS FOR THE DESTINATION CONNECTION ALREADY EXIST IN AN ELASTIC FIFO MEMORY
107
A SECOND TEST IS PERFORMED: CAN AN ALLOCATOR OBTAIN ONE OR MORE CONNECTION-SPECIFIC RESOURCES REQUIRED TO SEND THE PACKET TO A VIRTUAL HOST CORRESPONDING TO THE DESTINATION CONNECTION?
105
NO
YES
IF THE ALLOCATOR OBTAINS ONE OR MORE CONNECTION-SPECIFIC RESOURCES, A SEND ENGINE WRITES THE PACKET TO A VIRTUAL HOST MEMORY
109
END
IF THE PARSER DOES NOT DETERMINE A DESTINATION CONNECTION FOR THE PACKET, THE PACKET IS PASSED TO A STORE ENGINE
111
IF THE ALLOCATOR FAILS IN THE ATTEMPT TO OBTAIN ONE OR MORE CONNECTION-SPECIFIC RESOURCES, THE ALLOCATOR PASSES THE PACKET TO THE STORE ENGINE
113
THE STORE ENGINE OBTAINS A FREE PACKET BUFFER FROM THE ELASTIC FIFO MEMORY, WHEREIN THE FREE PACKET BUFFER IS AN EMPTY PACKET-SIZED BLOCK OF MEMORY IN A LOCAL DATA STORE
115
A

FIG. 1A

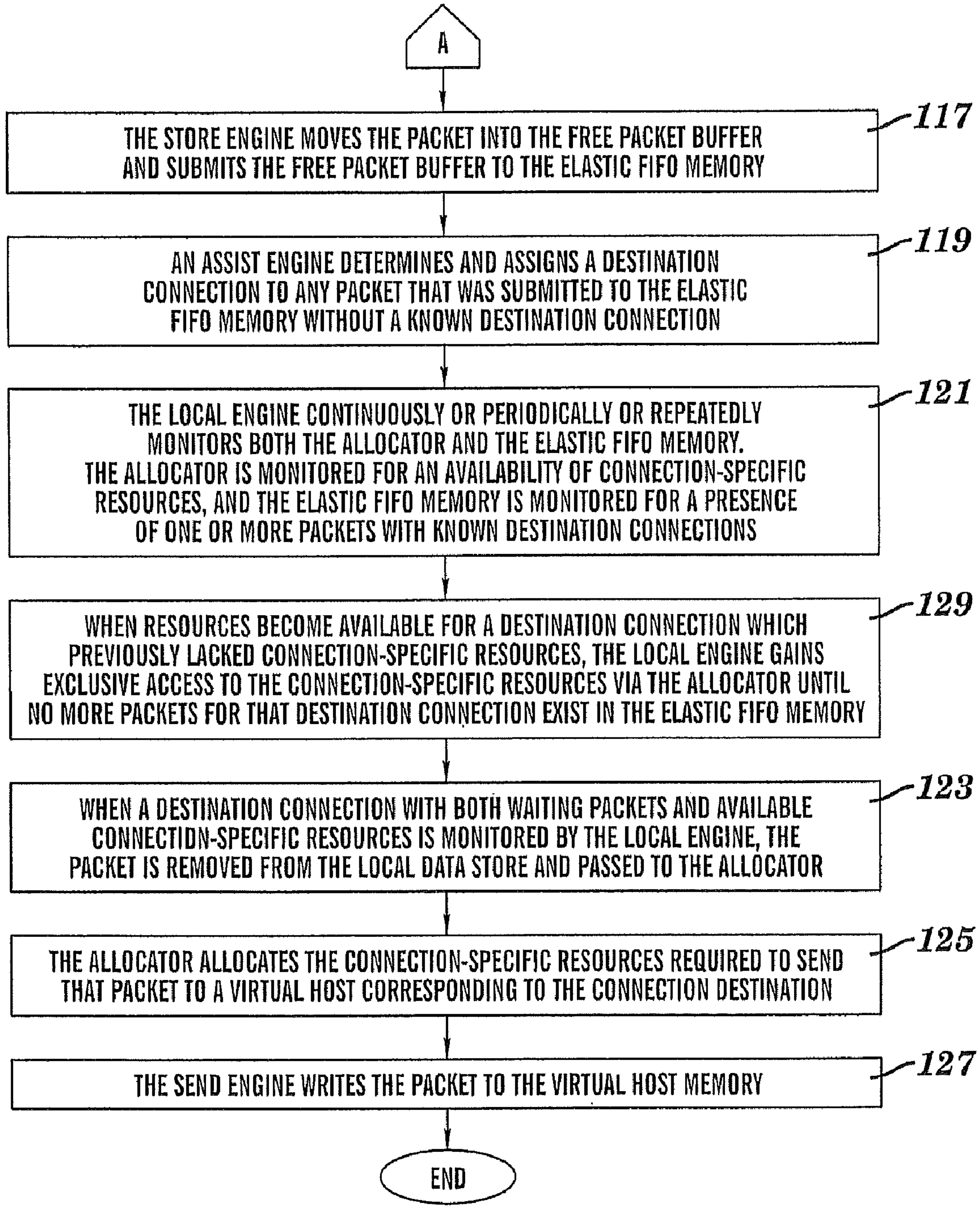

A
THE STORE ENGINE MOVES THE PACKET INTO THE FREE PACKET BUFFER AND SUBMITS THE FREE PACKET BUFFER TO THE ELASTIC FIFO MEMORY
117
AN ASSIST ENGINE DETERMINES AND ASSIGNS A DESTINATION CONNECTION TO ANY PACKET THAT WAS SUBMITTED TO THE ELASTIC FIFO MEMORY WITHOUT A KNOWN DESTINATION CONNECTION
119
THE LOCAL ENGINE CONTINUOUSLY OR PERIODICALLY OR REPEATEDLY MONITORS BOTH THE ALLOCATOR AND THE ELASTIC FIFO MEMORY. THE ALLOCATOR IS MONITORED FOR AN AVAILABILITY OF CONNECTION-SPECIFIC RESOURCES, AND THE ELASTIC FIFO MEMORY IS MONITORED FOR A PRESENCE OF ONE OR MORE PACKETS WITH KNOWN DESTINATION CONNECTIONS
121
WHEN RESOURCES BECOME AVAILABLE FOR A DESTINATION CONNECTION WHICH PREVIOUSLY LACKED CONNECTION-SPECIFIC RESOURCES, THE LOCAL ENGINE GAINS EXCLUSIVE ACCESS TO THE CONNECTION-SPECIFIC RESOURCES VIA THE ALLOCATOR UNTIL NO MORE PACKETS FOR THAT DESTINATION CONNECTION EXIST IN THE ELASTIC FIFO MEMORY
129
WHEN A DESTINATION CONNECTION WITH BOTH WAITING PACKETS AND AVAILABLE CONNECTION-SPECIFIC RESOURCES IS MONITORED BY THE LOCAL ENGINE, THE PACKET IS REMOVED FROM THE LOCAL DATA STORE AND PASSED TO THE ALLOCATOR
123
THE ALLOCATOR ALLOCATES THE CONNECTION-SPECIFIC RESOURCES REQUIRED TO SEND THAT PACKET TO A VIRTUAL HOST CORRESPONDING TO THE CONNECTION DESTINATION
125
THE SEND ENGINE WRITES THE PACKET TO THE VIRTUAL HOST MEMORY
127
END

FIG. 1B

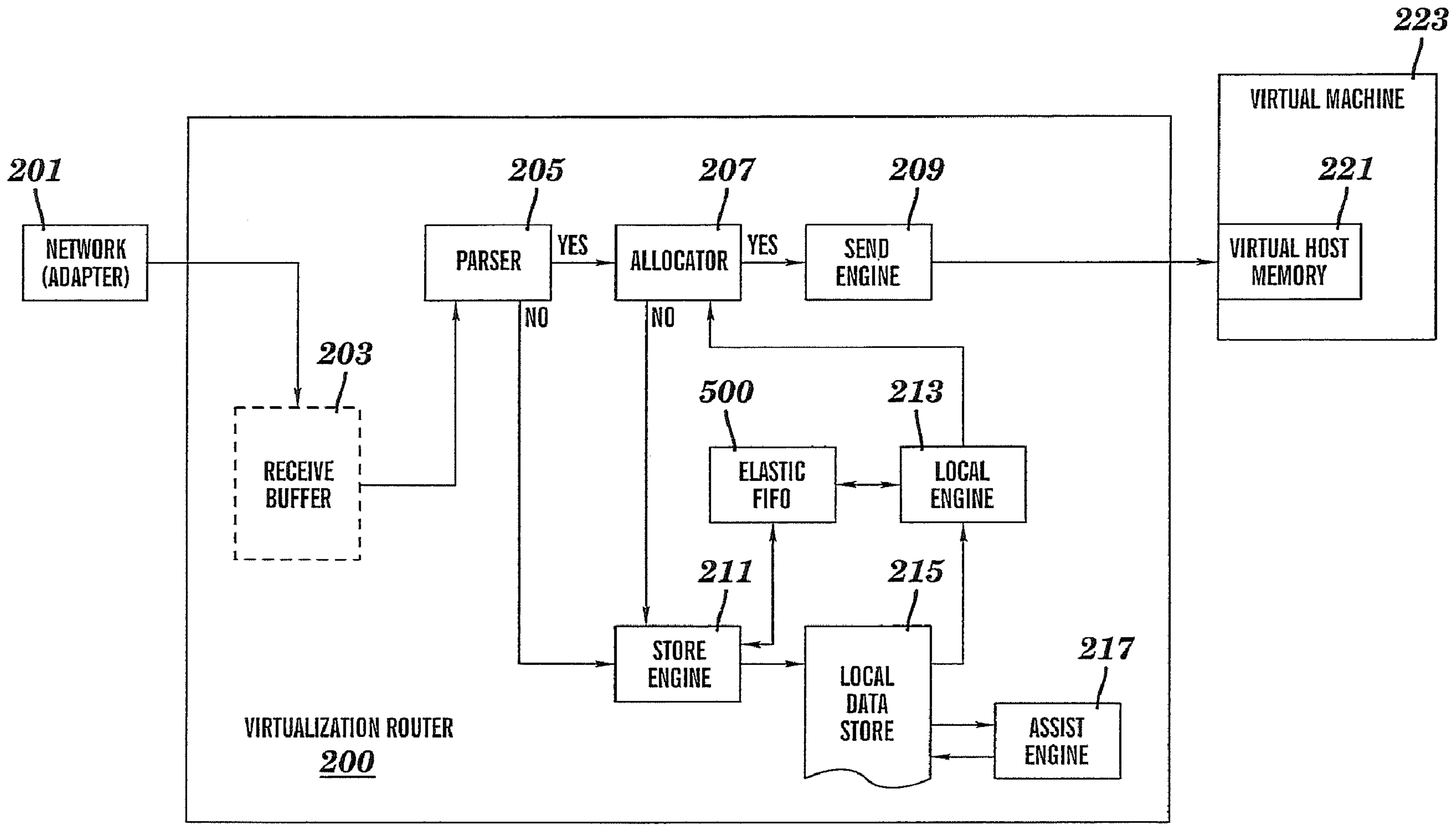

201
NETWORK (ADAPTER)
203
RECEIVE BUFFER
205
PARSER
YES
NO
207
ALLOCATOR
YES
NO
209
SEND ENGINE
500
ELASTIC FIFO
213
LOCAL ENGINE
211
STORE ENGINE
215
LOCAL DATA STORE
217
ASSIST ENGINE
VIRTUALIZATION ROUTER
200
223
VIRTUAL MACHINE
221
VIRTUAL HOST MEMORY

FIG. 2

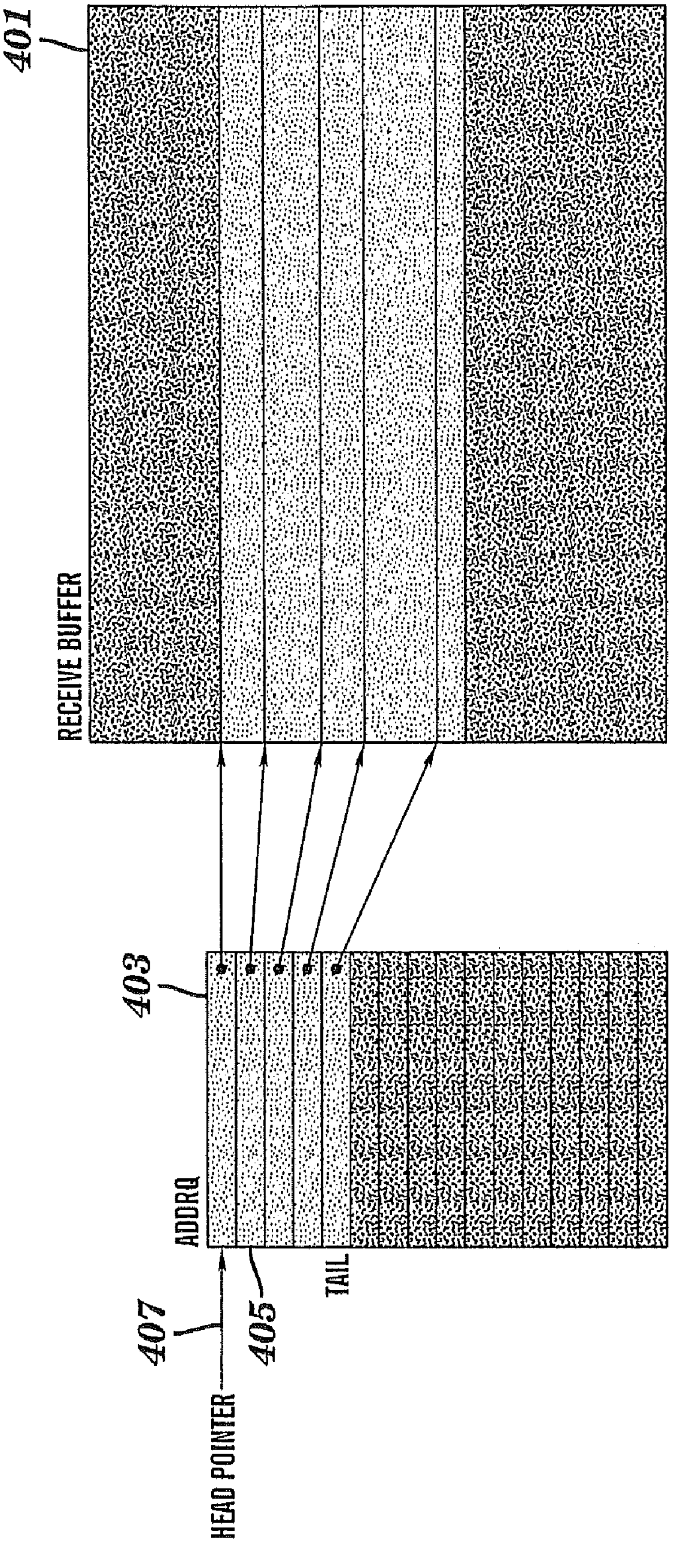


FIG. 3

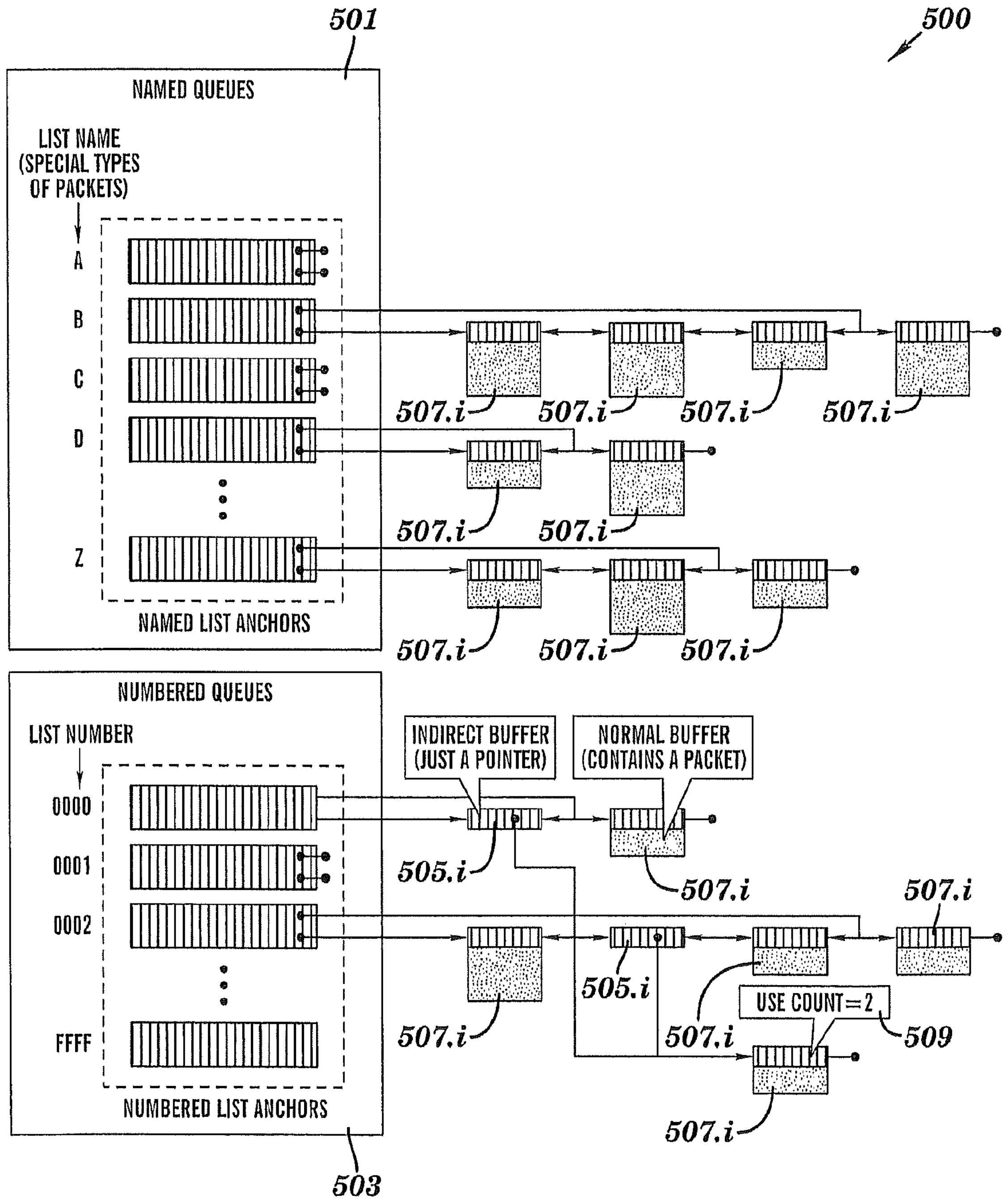

501
500
NAMED QUEUES
LIST NAME (SPECIAL TYPES OF PACKETS)
A
B
C
D
Z
NAMED LIST ANCHORS
507.i
507.i
507.i
507.i
507.i
507.i
507.i
507.i
507.i
NUMBERED QUEUES
LIST NUMBER
0000
0001
0002
FFFF
NUMBERED LIST ANCHORS
INDIRECT BUFFER (JUST A POINTER)
NORMAL BUFFER (CONTAINS A PACKET)
505.i
507.i
507.i
505.i
507.i
507.i
USE COUNT=2
509
507.i
503

FIG. 4

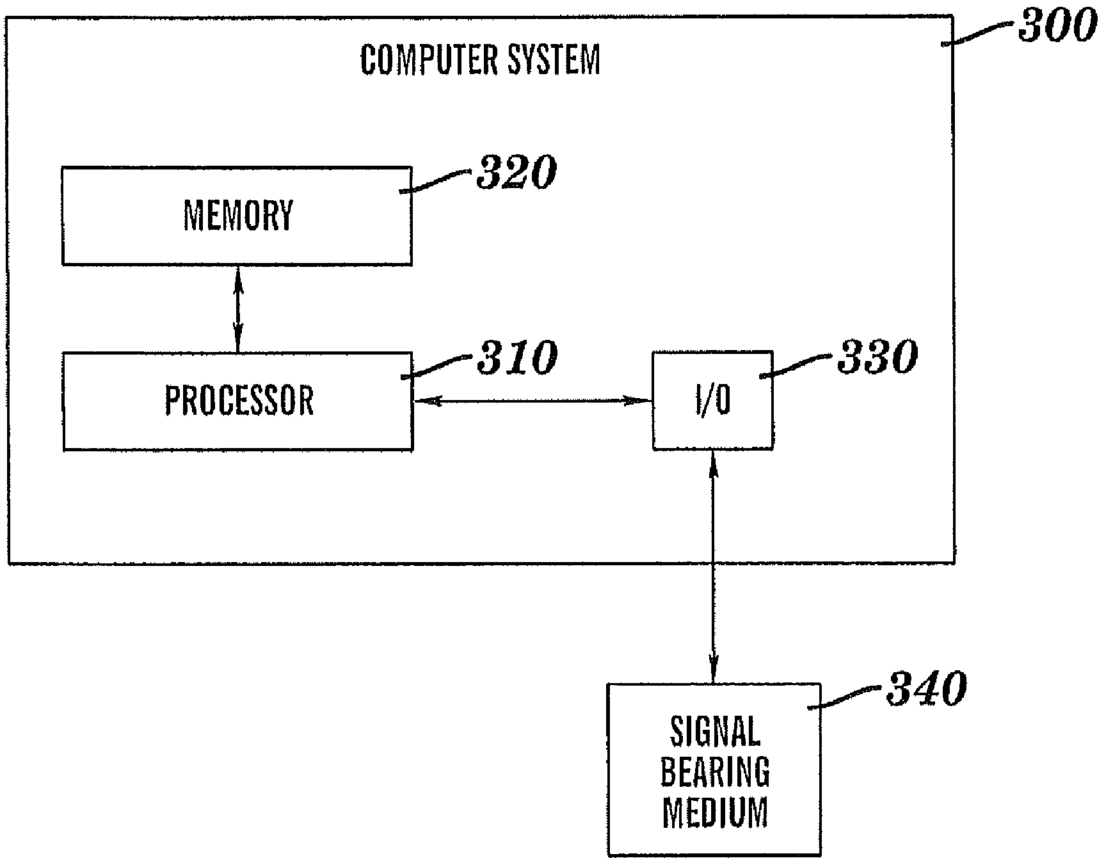

COMPUTER SYSTEM
300
MEMORY
320
PROCESSOR
310
I/O
330
SIGNAL BEARING MEDIUM
340

FIG. 5

METHOD, SYSTEM, AND COMPUTER PROGRAM PRODUCT FOR ETHERNET VIRTUALIZATION USING AN ELASTIC FIFO MEMORY TO FACILITATE FLOW OF UNKNOWN TRAFFIC TO VIRTUAL HOSTS

BACKGROUND OF THE INVENTION

This invention relates generally to network virtualization and, more particularly, to methods, systems, computer program products, and hardware products for implementing Ethernet virtualization routers using an elastic FIFO memory to facilitate flow of unknown traffic to virtual hosts.

A shortcoming with existing network virtualization techniques is that routers which service a relatively large number of communication channels are oftentimes not able to achieve the necessary bandwidth to keep packets moving. As congestion builds, the router may place back pressure on a network to avoid accepting additional packets, or packets may be dropped altogether. Moreover, a shortage in channel-specific resources for one or two channels may cause packet throughput in other channels to suffer as well. Accordingly, it would be advantageous to provide an enhanced technique for Ethernet virtualization that overcomes the foregoing deficiencies and that is capable of expeditiously moving packets to a desired destination connection.

BRIEF SUMMARY OF THE INVENTION

Exemplary embodiments include a method for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to virtual hosts. The method comprises receiving a packet that represents unknown traffic on a network and destined for a virtual host; performing a first test to ascertain whether or not a destination connection can be determined for the received packet wherein, if a destination connection can be determined, a second test is performed to ascertain whether or not one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection are available; if a destination connection for the packet cannot be determined, passing the packet to a store engine; if the one or more connection-specific resources are not available, passing the packet to the store engine; the store engine obtaining a free packet buffer from an elastic first-in, first-out (FIFO) memory, wherein the free packet buffer is an empty packet-sized block of memory in a local data store; the store engine moving the packet into the free packet buffer and submitting the free packet buffer to the elastic FIFO memory; performing a monitoring procedure to detect both an availability of connection-specific resources and a presence of one or more waiting packets with a known destination connection; when a destination connection with: (i) one or more waiting packets, and (ii) available connection-specific resources; are both detected, removing the packet from the local data store; allocating the one or more connection-specific resources required to send the packet to the virtual host memory corresponding to the connection destination; and writing the packet to the virtual host memory.

A system, and a computer program product corresponding to the above-summarized method is also described and claimed herein. Other systems, methods, and computer program products according to embodiments will be or become apparent to one with skill in the art upon review of the following drawings and detailed description. It is intended that all such additional systems, methods, and computer program products be included within this description, be within the scope of the present invention, and be protected by the accompanying claims.

Additional features and advantages are realized through the techniques of the present invention. Other embodiments and aspects of the invention are described in detail herein and are considered a part of the claimed invention. For a better understanding of the invention with advantages and features, refer to the description and to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the drawings wherein like elements are numbered alike in the several FIGURES:

FIGS. **1**A and **1**B together comprise a flowchart setting forth an illustrative operational sequence for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host;

FIG. **2** is a block diagram setting forth an illustrative system for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host;

FIG. **3** is a data structure diagram setting forth an illustrative receive buffer for use with the system of FIG. **2**;

FIG. **4** is a data structure diagram setting forth an illustrative elastic FIFO for use with the system of FIG. **2**; and

FIG. **5** is a block diagram setting forth an illustrative computer program product for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host.

The detailed description explains the preferred embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

An exemplary embodiment of the present invention permits a hardware Ethernet virtualization router which serves a large number of communications channels to maintain high bandwidth by ensuring that packets can continue moving. The router avoids having to place back pressure on the network or having to drop packets, which are undesirable alternatives to moving packets. Thus, the technical effects and benefits include allowing an Ethernet virtualization router servicing any number of communications channels to continually move traffic efficiently regardless of packet types or shortages in channel-specific resources. High bandwidth can be maintained in spite of the unpredictable and bursty traffic patterns inherent to Ethernet networks. Packet order is maintained on a host-by-host basis and does not stall the flow of packets to one virtual machine because of a shortage of resources required for another virtual machine. Packets requiring special attention, such as multicast packets, packets for which connections cannot be determined by a parser, or address resolution protocol (ARP) packets, may also be handled using the methods disclosed herein.

FIGS. **1**A and **1**B together comprise a flowchart setting forth an illustrative operational sequence for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host, and FIG. **2** is a block diagram setting forth an illustrative system for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host. Although FIGS. **1**A and **1**B show a linearly sequential series of operations, this is solely for purposes of clarity and illustration, as some of the steps could be performed in parallel or in a sequence other than what is shown in FIGS. **1**A and **1**B. The operational sequence of FIGS. **1**A and **1**B commences at block **101** (FIG. **1**A) where a packet is received that represents unknown traffic destined for a virtual host. The packet is received from a network. The received packet includes a header. Illustratively, the received packet may be written into a relatively small optional receive buffer **203** (FIG. **2**) as the packet arrives from a network adapter **201**. The receive buffer **203** is not strictly required.

At block **103** (FIG. **1**A), a parser **205** (FIG. **2**) examines each packet's headers (for example, layer 2, layer 3, etc.) and a first test is performed to ascertain whether or not a destination connection can be determined for the received packet. The affirmative branch from block **103** leads to block **107**, and the negative branch from block **103** leads to block **111** (described in greater detail hereinafter). If the parser **205** (FIG. **2**) can determine a destination connection for the packet, following block **107** at block **105** (FIG. **1**A), a second test is performed to ascertain whether or not one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection are available. The one or more connection-specific resources are available if they can be obtained for allocation by a resource allocation mechanism such as an allocator **207** (FIG. **2**). For example, the allocator **207** attempts to obtain one or more connection-specific resources required to send that packet to a virtual machine **223** that corresponds to the destination connection. Note that the terms "virtual machine" and "virtual host" are used interchangeably herein. The affirmative branch from block **105** leads to block **109** (to be described in greater detail hereinafter), whereas the negative branch from block **105** leads to block **113** (to be described in greater detail hereinafter).

Although the illustrative configuration of FIG. **2** shows one virtual machine **223**, this is for purposes of clarity, as the system of FIG. **2** may contain a plurality of virtual machines. For example, a practical system may include hundreds or thousands of virtual machines. With hundreds or thousands of virtual machines running on a single physical host, there may be scattered shortages of resources for some small subset of the virtual machines at any given time. Within the physical machine, a hypervisor may allocate differing resources to different virtual machines. For example, some virtual machines may have higher priority and therefore get more time-slices than others. Or, some virtual machines may have more physical storage allocated for use as receive buffers. A real-world system hosting thousands of virtual machines may not operate perfectly at all times with regard to resource management. Likewise, scattered resource shortages may be attributed to the inherently bursty nature of Ethernet traffic.

At block **107** (FIG. **1**A), a local engine **213** (FIG. **2**) blocks the allocator **207** from allocating resources to new packets when packets for the same connection already exist within an elastic first-in, first-out (FIFO) **500** memory because of a previous lack of resources. At block **109** (FIG. **1**A), if the allocator **207** is successful in obtaining the resources, a send engine **209** (FIG. **2**) writes the packet to a virtual host memory **221** associated with the virtual machine **223**. If the parser **205** does not determine the packet's connection (FIG. **1**A, block **111**), it passes the packet to a store engine **211** (FIG. **2**). At block **113** (FIG. **1**A), if the allocator **207** (FIG. **2**) fails in its attempt to obtain the required resources (which could be because the resources are not available or because the local engine currently has priority access to those resources), the allocator **207** passes the packet to the store engine **211**.

Next, at block **115** (FIG. **1**A), for each packet it is to service, the store engine **211** (FIG. **2**) obtains a free packet buffer from the elastic FIFO **500**. A free packet buffer is an empty packet-sized block of memory in a local data store **215**. The store engine **211** moves the packet into that buffer (FIG. **1**B, block **117**) and submits the used buffer to the elastic FIFO **500** (FIG. **2**). If a free packet buffer resource is not available, the packet is dropped or, optionally, the store engine **211** can wait for that shared resource to become available provided sufficient buffering, such as the receive buffer, is available. Since a packet's connection must be determined before it can be sent to the virtual host memory **221**, at block **119** (FIG. **1**B) an assist engine **217** (FIG. **2**) determines and assigns connections to packets that were submitted to the elastic FIFO **500** without known connections (i.e. those packets which arrived from the parser **205**).

The procedure of FIGS. **1**A and **1**B progresses to block **121** (FIG. **1**B) where the local engine **213** (FIG. **2**) continuously or periodically or repeatedly monitors both the allocator **207** for connection-specific resources and the elastic FIFO **500** for the presence of packets with known destination connections. When resources become available for a connection which had previously lacked resources, block **129**, the local engine **213** (FIG. **2**) gains exclusive access to those resources, via the allocator **207**, until no more packets for that connection exist in the elastic FIFO **500**. The operations of block **129** (FIG. **1**B) are critical to maintaining packet order within destination connections. At block **123** (FIG. **1**B), when a connection with both waiting packets and available resources is seen, the packet is removed from the local data store **215** (FIG. **2**) and passed to the allocator **207**. The allocator **207** allocates the connection-specific resources required to send that packet to a virtual machine **223** corresponding to the connection destination (FIG. **1**B, block **125**). Since the local engine **213** (FIG. **2**) already determined that the resources were available and claimed them for the packet, the allocator **207** is successful and the packet is written to virtual host memory **221** by the send engine **209** at block **127** (FIG. **1**B).

The parser **205** (FIG. **2**), allocator **207**, send engine **209**, store engine **211**, local engine **213**, local data store **215**, elastic FIFO **500**, and assist engine **217** together comprise a virtualization router **200**. The router **200** is referred to as a virtualization router because it supports communication channels to a plurality of virtual machines which are called destination connections, such as virtual machine **223**, providing the illusion to each virtual machine **223** that it possesses its own network interface card (such as the network adapter **201**), when in fact only a single high-speed adapter (i.e., the network adapter **201**) is present. The network adapter **201** is run in promiscuous mode to receive all packets off the network. The router **200** determines the correct connection for each packet and moves the packet to a memory space (i.e., virtual host memory **221**) of a corresponding virtual machine **223**.

Inbound Ethernet traffic flow is inherently bursty. Multiple shared and non-shared resources are required for each connection in order to move its packets. With inherently limited resources which must be carefully managed, one of the functions performed by the router **200** is to handle the bursty traffic in such a way as to minimize packet loss and retransmission for each connection in the context of virtual hosts, thereby maximizing network efficiency.

FIG. **3** is a data structure diagram setting forth an illustrative receive buffer **401** for implementing the optional receive buffer **203** of FIG. **2**. Incoming bursts of packet data are initially written directly into the receive buffer **401** (FIG. **3**), which is managed with a queue of records called an addrq **403**. Each record **405** contains various information about a burst including a pointer into the receive buffer **401** where the data was written. All packets are removed from the receive buffer **401** in the same order that they were previously written (as the packets arrived from the network adapter **201**, FIG. **2**). If the packet at the head of the addrq **403** (FIG. **3**) as indicated by a head pointer **407** is not a type of packet that requires special handling and if all required resources are available to move the packet, the packet is sent directly to its connection destination (virtual host memory **221**, FIG. **2**). Otherwise, if the packet is a special type or if one or more of the resources is not available, the packet is sent to the elastic FIFO **500**.

As the head pointer **407** (FIG. **3**) moves forward (i.e., in a downward direction wherein FIG. **3** is oriented such that the reference numerals are upright), packets for connections with ample resources continue to be sent directly to their connection destinations even while packets for other connections without resources are sent to the elastic FIFO **500** (FIG. **2**). Similarly, by the same mechanism, packets that do not require special consideration can be sent directly to their destinations while packets that require extra processing (e.g. multicast packets) can be sent to the elastic FIFO **500** to be serviced by an independently-running assist engine. In this way, the flow of all packets continues through the router **200** consistently without stalls or hesitations.

FIG. **4** is a data structure diagram setting forth an illustrative elastic FIFO **500** memory (FIGS. **2** and **4**) for use with the system of FIG. **2** and the method of FIG. **1**. The elastic FIFO **500** (FIG. **4**) includes a large array of linked lists of packet buffers, as well as all the functionality required to maintain those lists and allow them to be put to a useful purpose. The elastic FIFO **500** serves to manage the flow of packets that can not be sent directly from the receive buffer **203** (FIG. **2**) to one of the virtual machines such as the virtual machine **223**. The elastic FIFO **500** (FIG. **4**) is called “elastic” because it changes shape with changes in either or both of: (a) the number of active connections, or (b) the total number of packets contained by the FIFO. In its entirety, the memory footprint of the elastic FIFO **500** can be increased or decreased over time as free buffers are dynamically added or removed.

The elastic FIFO **500** is also called “elastic” because it is actually a collection of queues on which packet buffers and pointers to packet buffers are held. These pointers to packet buffers are shown in FIG. **4** as indirect buffers **505**.*i*, where i is any positive integer greater than zero. The packet buffers are shown in FIG. **4** as normal buffers **507**.*j* where j is any positive integer greater than zero. There are named queues **501** for free normal buffers **507**.*j* of various sizes. These named queues **501** also include a named queue for free indirect buffers **505**.*i*. Indirect buffers **505**.*i* only occupy a small amount of memory, as they merely point to a normal buffer **507**.*j*, but these indirect buffers **505**.*i* do occupy some memory and are thus obtained as needed from the free list so that they may be enqueued to a numbered list. Since the elastic FIFO **500** is elastic, additional free indirect buffers **505**.*i* can be added as necessary, and these buffers may also be taken away if the free list becomes excessively long. There is no direct relationship between the total number of indirect buffers **505**.*i* and normal buffers **507**.*j*. At any given time, some number of the normal buffers **507**.*j* will be occupied by packets, though ideally most should be free most of the time.

There are two categories of queues within the elastic FIFO **500**: named queues **501** and numbered queues **503**. When a packet is sent to the elastic FIFO **500** because it requires special consideration, it is placed on a named queue of named queues **501**, as opposed to being placed on a numbered connection queue of numbered queues **503**. Each named queue of named queues **501** includes a list name A, B, C, D, Z that reflects a special packet type placed on that queue. Packets placed on named queues **501** must ultimately be moved to numbered queues **503**. Packets on a numbered queue of numbered queues **503** can be sent to a corresponding destination connection’s virtual host memory **221** (FIG. **2**) as soon as the required connection-specific resources are available.

Named queues **501** (FIG. **4**) are also used for implementing pools of various types of free buffers, which are buffers that are not currently associated with a packet. A free buffer is obtained for each packet that is to be locally stored, and that buffer is returned to the pool from which it originated once the packet has been removed from local storage and sent to virtual host memory **221** (FIG. **2**). When the special packet type is multicast or broadcast, the packet must be moved from a “multicast” or “broadcast” named queue of named queues **501** (FIG. **4**) to a plurality of numbered queues in numbered queues **503** so it may be sent to multiple virtual machines including virtual machine **223** (FIG. **2**), wherein potentially thousands of such virtual machines are present. The assist engine **217** efficiently performs this task through the use of indirect buffers **505**.*i* (FIG. **4**).

There are two types of packet buffers that may be put on a numbered queue of numbered queues **503**: normal buffers **507**.*j* and indirect buffers **505**.*i*. Indirect buffers **505**.*i* do not contain data themselves, but merely point to a normal buffer **507**.*j*. The assist engine **217** (FIG. **2**) removes a normal buffer **507**.*j* (FIG. **4**) from a named queue of named queues **501**, obtains multiple free indirect buffers **505**.*i* from the elastic FIFO **500**, points those indirect buffers **505**.*i* at the normal buffer **507**.*j*, and enqueues those indirect buffers **505**.*i* to the appropriate numbered queues **503**.

Every normal buffer **507**.*j* carries a use count **509**. A normal buffer’s use count **509** is usually 1 but can be higher when the normal buffer **507**.*j* is the target of an indirect buffer **505**.*i*. A normal buffer **507**.*j* that is directly sitting on a queue has a use count of 1, while a normal buffer **507**.*j* pointed to by one or more indirect buffers **505**.*i* (which are sitting on one or more queues) has a use count equal to the number of indirect buffers **505**.*i* pointing to it. A normal buffer **507**.*j* that is the target of an indirect buffer **505**.*i* can not itself directly exist on any queue. Each time a copy of the packet in the normal buffer **507**.*j* is sent to virtual host memory **221** (FIG. **2**), an indirect buffer **505**.*i* (FIG. **4**) pointing to it is removed from a numbered queue of numbered queues **503** and the normal buffer’s use count **509** is decremented by 1 (provided it is still greater than 1). When the normal buffer’s use count **509** reaches 1, it is returned to the pool of free normal buffers **507**.*j* at the same time a final indirect buffer **505**.*i* pointing to the normal buffer **507**.*j* is dequeued and returned to the pool of free indirect buffers **505**.*i*.

The local engine **213** (FIG. **2**) performs the task of dequeuing buffers from the numbered queues **503** (FIG. **4**), via the interface provided by the elastic FIFO **500**, so the packets contained within or pointed to by those buffers can be sent to virtual host memory **221** (FIG. **2**). As soon as the allocator **207** fails to obtain virtual host memory **221** for one packet for a given connection, it must send all subsequent packets for that connection to the local data store **215** in order to maintain packet order for that connection. One task performed by the local engine **213** is to empty queues containing packets that have accumulated, due to resource shortages, so packets may once again flow directly from the network adapter **201** to virtual host memory **221**, i.e. without being stored first. The local engine **213** obtains exclusive access to connection-specific resources until the local engine determines that it has emptied a destination connection’s queue and relinquishes that exclusivity.

FIG. **5** is a block diagram setting forth an illustrative computer program product for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host. The system includes a computer **300** operatively coupled to a signal bearing medium **340** via an input/output interface (I/O) **330**. The signal bearing medium **340** may include a representation of instructions for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host, and may be implemented as, e.g., information permanently stored on non-writeable storage media (e.g., read-only memory devices within a computer, such as CD-ROM disks readable by a CD-ROM drive), alterable information stored on a writeable storage media (e.g., floppy disks within a diskette drive or hard disk drive), information conveyed to a computer by a communications medium, such as through a computer or telephone network, including wireless or broadband communications networks, such as the Internet, etc.

The computer **300** includes a processor **310** that processes information for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host, wherein the information is represented, e.g., on the signal bearing medium **340** and communicated to the computer **300** via the I/O **330**, wherein the processor **310** saves information as appropriate into a memory **320**. Illustratively, the processor **310** corresponds to the processing mechanism **106** of FIG. **1**. Returning now to FIG. **6**, this information may also be saved into the memory **320**, e.g., via communication with the I/O **330** and the signal bearing medium **340**.

The processor **310** executes a program for implementing Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host. The processor **310** implements instructions for receiving a packet that represents unknown traffic destined for a virtual host on a network; performing a first test to ascertain whether or not a destination connection can be determined for the received packet wherein, if a destination connection can be determined, a second test is performed to ascertain whether or not one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection are available; if a destination connection for the packet cannot be determined, passing the packet to a store engine; if the one or more connection-specific resources are not available, passing the packet to the store engine; the store engine obtaining a free packet buffer from an elastic first-in, first-out (FIFO) memory, wherein the free packet buffer is an empty packet-sized block of memory in a local data store; the store engine moving the packet into the free packet buffer and submitting the free packet buffer to the elastic FIFO memory; performing a monitoring procedure to detect both an availability of connection-specific resources and a presence of one or more waiting packets with a known destination connection; when a destination connection with: (i) one or more waiting packets, and (ii) available connection-specific resources; are both detected, removing the packet from the local data store; allocating the one or more connection-specific resources required to send the packet to the virtual host memory corresponding to the connection destination; and writing the packet to the virtual host memory. The foregoing steps may be implemented as a program or sequence of instructions within the memory **320**, or on a signal bearing medium, such as the medium **340**, and executed by the processor **310**.

As described above, the embodiments of the invention may be embodied in the form of computer-implemented processes and apparatuses for practicing those processes. Embodiments of the invention may also be embodied in the form of computer program code containing instructions embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, or any other computer-readable storage medium, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes an apparatus for practicing the invention. The present invention can also be embodied in the form of computer program code, for example, whether stored in a storage medium, loaded into and/or executed by a computer, or transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via electromagnetic radiation, wherein, when the computer program code is loaded into and executed by a computer, the computer becomes an apparatus for practicing the invention. When implemented on a general-purpose microprocessor, the computer program code segments configure the microprocessor to create specific logic circuits.

While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another.

We claim:

1. A method for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host, the method comprising:

receiving a packet that represents unknown traffic on a network;

performing a first test to ascertain whether or not a destination connection can be determined for the received packet wherein, if a destination connection can be determined, a second test is performed to ascertain whether or not one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection are available;

if a destination connection for the packet cannot be determined, passing the packet to a store engine;

if the one or more connection-specific resources are not available, passing the packet to the store engine;

the store engine obtaining a free packet buffer from an elastic first-in, first-out (FIFO) memory, wherein the free packet buffer is an empty packet-sized block of memory in a local data store;

the store engine moving the packet into the free packet buffer and submitting the free packet buffer to the elastic FIFO memory;

performing a monitoring procedure to detect both an availability of connection-specific resources and a presence of one or more waiting packets with a known destination connection;

when a destination connection with one or more waiting packets and available connection-specific resources; are both detected, removing the packet from the local data store;

allocating the one or more connection-specific resources required to send the packet to the virtual host memory corresponding to the destination connection; and

writing the packet to the virtual host memory.

2. The method of claim **1** wherein the first test is performed by examining a header of the packet, the method further including storing the received packet in a receive buffer.

3. The method of claim **1** wherein the one or more connection-specific resources are rendered as unavailable if one or more additional packets for the destination connection already exist in the elastic FIFO memory.

4. The method of claim **1** wherein, if one or more connection-specific resources are available as determined by the second test, writing the packet to the virtual host memory.

5. The method of claim **1** wherein a destination connection is determined for and assigned to any packet that has been submitted to the elastic FIFO memory without a known destination connection.

6. The method of claim **1** wherein, when resources become available for a destination connection for which one or more connection-specific resources were previously unavailable, granting exclusive access to the one or more connection-specific resources for the destination connection.

7. The method of claim **6** further including terminating the exclusive access when no more packets for that destination connection exist in the elastic FIFO memory.

8. A system for Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host, the system comprising:

a parser configured to receive a packet representing unknown traffic on a network and to attempt to determine a destination connection for the packet;

an allocator; operatively coupled to the parser, the allocator configured to attempt to obtain one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection, the attempting responsive to the parser determining a destination connection for the packet;

a store engine operatively coupled to the allocator, the store engine configured to receive the packet, wherein if the parser does not determine a destination connection for the packet, the parser passes the packet to the store engine and wherein, if the allocator fails in the attempt to obtain the one or more connection-specific resources, the allocator passes the packet to the store engine;

an elastic first-in, first-out (FIFO) memory operatively coupled to the store engine, the FIFO memory configured to store a free packet buffer, wherein the store engine obtains the free packet buffer from the elastic FIFO memory, and wherein the free packet buffer is an empty packet-sized block of memory in a local data store; the store engine moving the packet into the free packet buffer and submitting the free packet buffer to the elastic FIFO memory;

a local engine configured to monitor both the allocator and the elastic FIFO memory; the allocator being monitored for an availability of connection-specific resources, and the elastic FIFO memory being monitored for a presence of one or more waiting packets with a known destination connection; wherein, when a destination connection with both one or more waiting packets and available connection-specific resources is monitored by the local engine, the packet is removed from the local data store and passed to the allocator; and wherein the allocator allocates the one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection; and

a send engine operatively coupled to the allocator, the send engine configured to write the packet to the virtual host memory.

9. The system of claim **8** wherein the parser is further configured to examine a header of the packet, and the system further includes a receive buffer operatively coupled to the parser configured to store the received packet.

10. The system of claim **8** wherein the one or more connection-specific resources are rendered as unavailable if one or more additional packets for the destination connection already exist in the elastic FIFO memory.

11. The system of claim **8** wherein the packet is written to the virtual host memory in response to one or more connection-specific resources being obtained by the allocator.

12. The system of claim **8** wherein a destination connection is determined for and assigned to any packet that has been submitted to the elastic FIFO memory without a known destination connection.

13. The system of claim **8** wherein, when resources are obtained for a destination connection for which one or more connection-specific resources were previously unavailable, granting exclusive access to the local engine to obtain the one or more connection-specific resources for the destination connection.

14. The system of claim **13** wherein the local engine is further configured to terminate the exclusive access when no more packets for that destination connection exist in the elastic FIFO memory.

15. A computer program product for facilitating Ethernet virtualization using an elastic FIFO memory to facilitate flow of unknown traffic to a virtual host, the computer program product comprising:

a tangible storage medium readable by a processing circuit and storing instructions for execution by the processing circuit for performing a method comprising:

receiving a packet that represents unknown traffic on a network;

performing a first test to ascertain whether or not a destination connection can be determined for the received packet wherein, if a destination connection can be determined, a second test is performed to ascertain whether or not one or more connection-specific resources required to send the packet to a virtual host memory corresponding to the destination connection are available;

if a destination connection for the packet cannot be determined, passing the packet to a store engine;

if the one or more connection-specific resources are not available, passing the packet to the store engine;

the store engine obtaining a free packet buffer from an elastic first-in, first-out (FIFO) memory, wherein the free packet buffer is an empty packet-sized block of memory in a local data store;

the store engine moving the packet into the free packet buffer and submitting the free packet buffer to the elastic FIFO memory;

performing a monitoring procedure to detect both an availability of connection-specific resources and a presence of one or more waiting packets with a known destination connection;

when a destination connection with one or more waiting packets and available connection-specific resources are both detected, removing the packet from the local data store;

allocating the one or more connection-specific resources required to send the packet to the virtual host memory corresponding to the destination connection destination; and

writing the packet to the virtual host memory.

16. The computer program product of claim **15** wherein the first test is performed by examining a header of the packet, and the method further comprises storing the received packet in a receive buffer.

17. The computer program product of claim **15** wherein the one or more connection-specific resources are rendered as unavailable if one or more additional packets for the destination connection already exist in the elastic FIFO memory.

18. The computer program product of claim **15** wherein, if one or more connection-specific resources are available as determined by the second test, writing the packet to the virtual host memory.

19. The computer program product of claim **15** wherein a destination connection is determined for and assigned to any packet that has been submitted to the elastic FIFO memory without a known destination connection.

20. The computer program product of claim **15** wherein, when resources become available for a destination connection for which one or more connection-specific resources were previously unavailable, granting exclusive access to the one or more connection-specific resources for the destination connection.

21. The computer program product of claim **20** wherein the method further comprises terminating the exclusive access when no more packets for that destination connection exist in the elastic FIFO memory.

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