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(54) **AGER RING OPTIMIZATION**

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G06F 15/173 (2006.01)
G06F 15/16 (2006.01)

(52) **U.S. Cl.** **709/223**; 709/251

(58) **Field of Classification Search** 709/223
See application file for complete search history.

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(57) **ABSTRACT**

A device provides an ager ring that ages entries associated with managed resource of a device, and determines whether a particular entry associated with a particular managed resource of the device is to be updated. The device also updates, when the particular entry is to be aged out in a particular time frame, the particular entry in the ager ring based on a bucket offset and a current time bucket associated with the particular entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring. The device further updates, when the particular entry is being aged during processing, the particular entry in the ager ring based on a new bucket, the current time bucket, and the bucket offset associated with the particular entry and based on the maximum timeout associated with the ager ring.

18 Claims, 10 Drawing Sheets

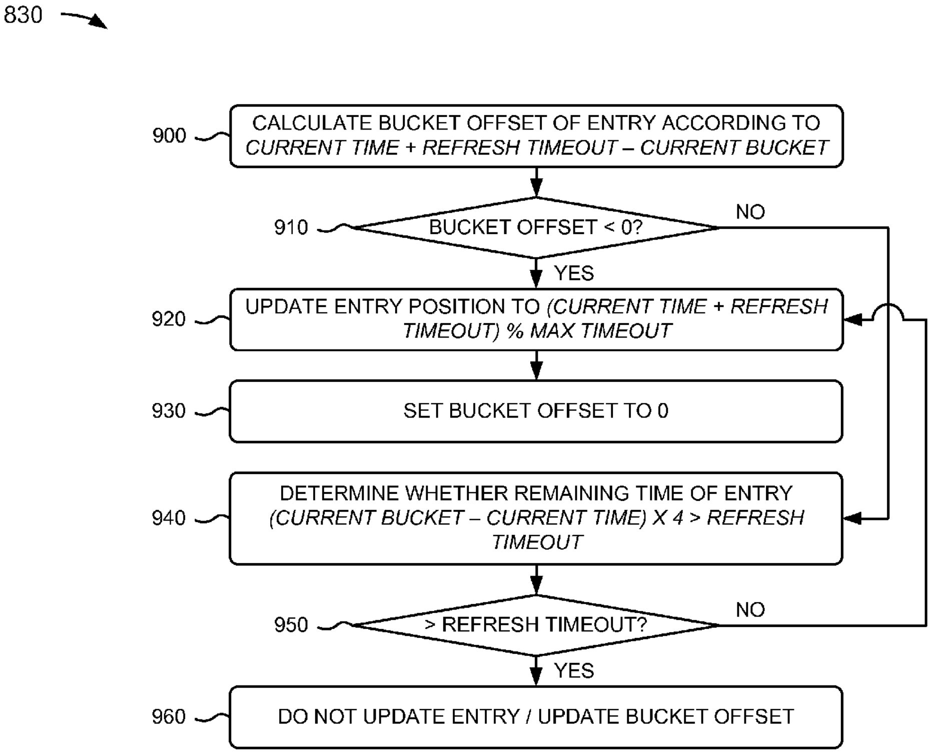

830
900
CALCULATE BUCKET OFFSET OF ENTRY ACCORDING TO *CURRENT TIME + REFRESH TIMEOUT – CURRENT BUCKET*
910
BUCKET OFFSET < 0?
NO
YES
920
UPDATE ENTRY POSITION TO *(CURRENT TIME + REFRESH TIMEOUT) % MAX TIMEOUT*
930
SET BUCKET OFFSET TO 0
940
DETERMINE WHETHER REMAINING TIME OF ENTRY *(CURRENT BUCKET – CURRENT TIME) X 4 > REFRESH TIMEOUT*
950
> REFRESH TIMEOUT?
NO
YES
960
DO NOT UPDATE ENTRY / UPDATE BUCKET OFFSET

FIG. 1

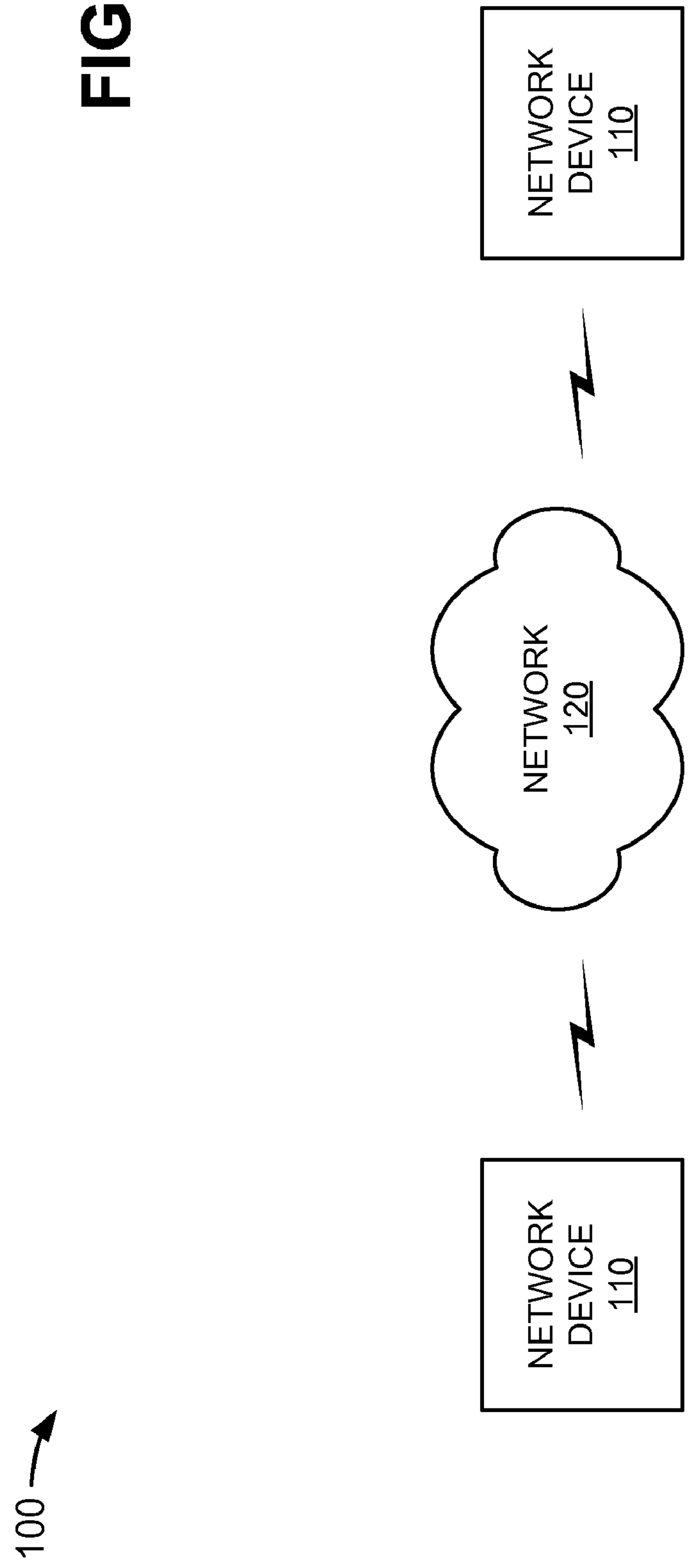
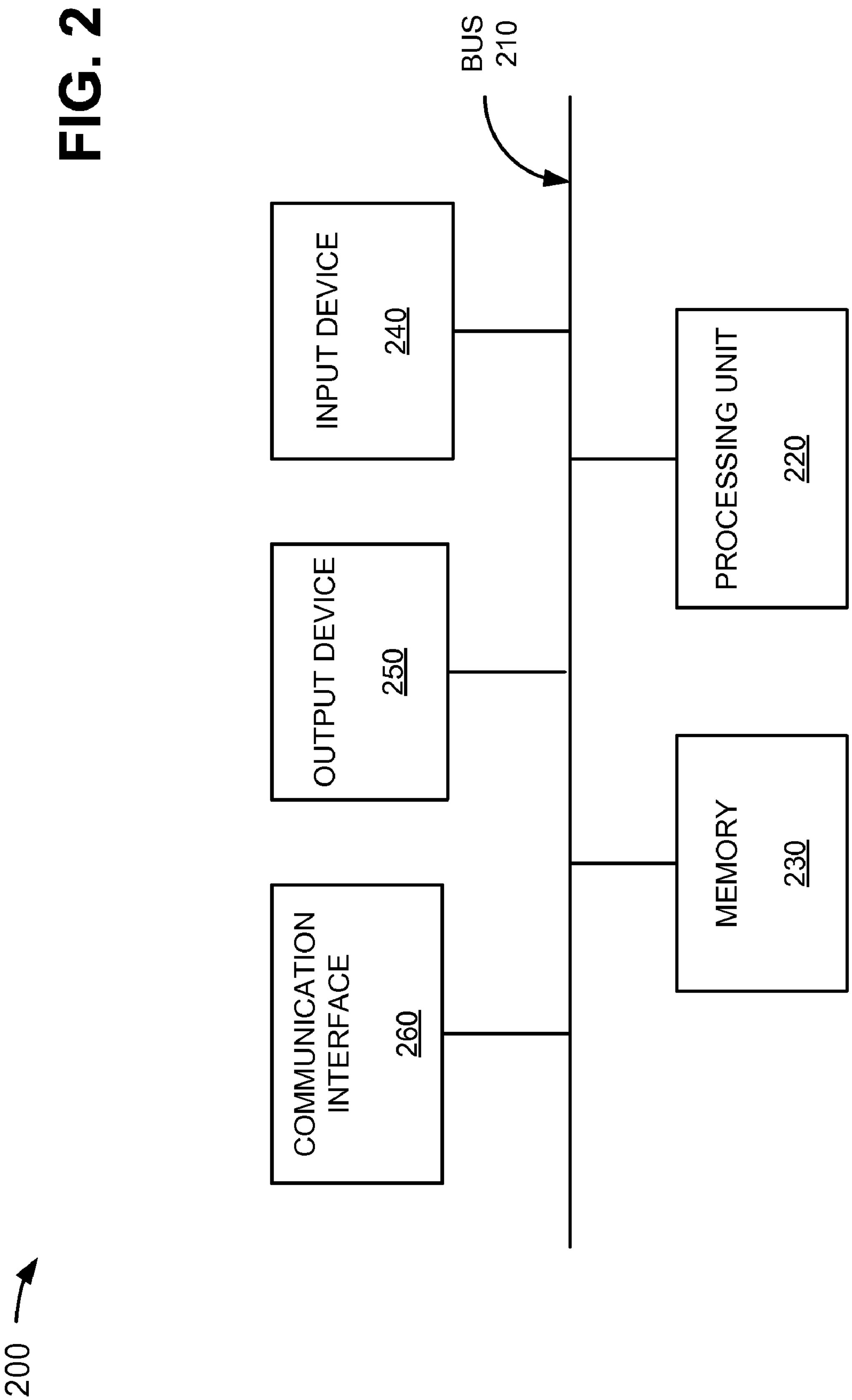


FIG. 2


200
BUS
210
INPUT DEVICE
240
OUTPUT DEVICE
250
COMMUNICATION
INTERFACE
260
PROCESSING UNIT
220
MEMORY
230

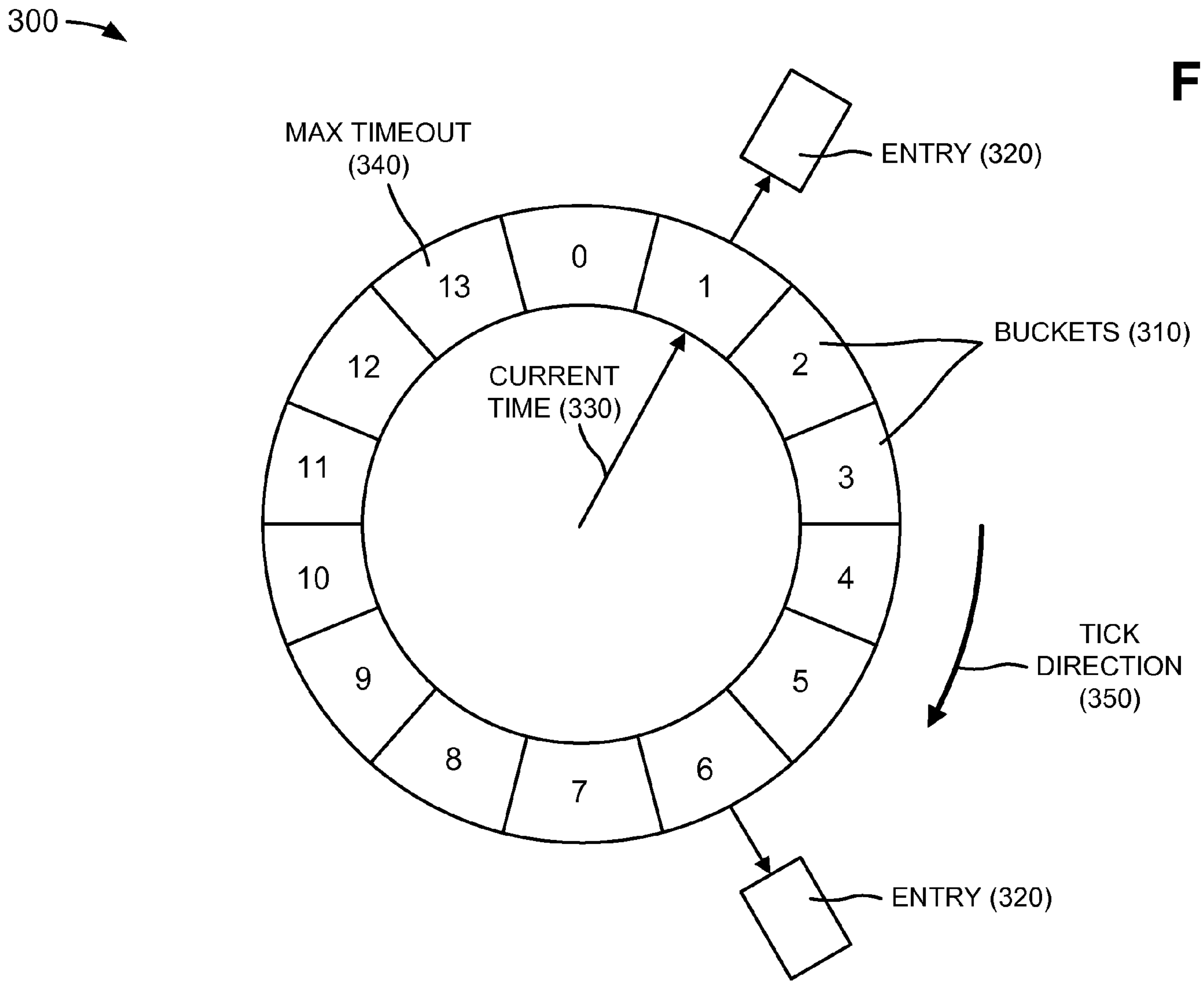
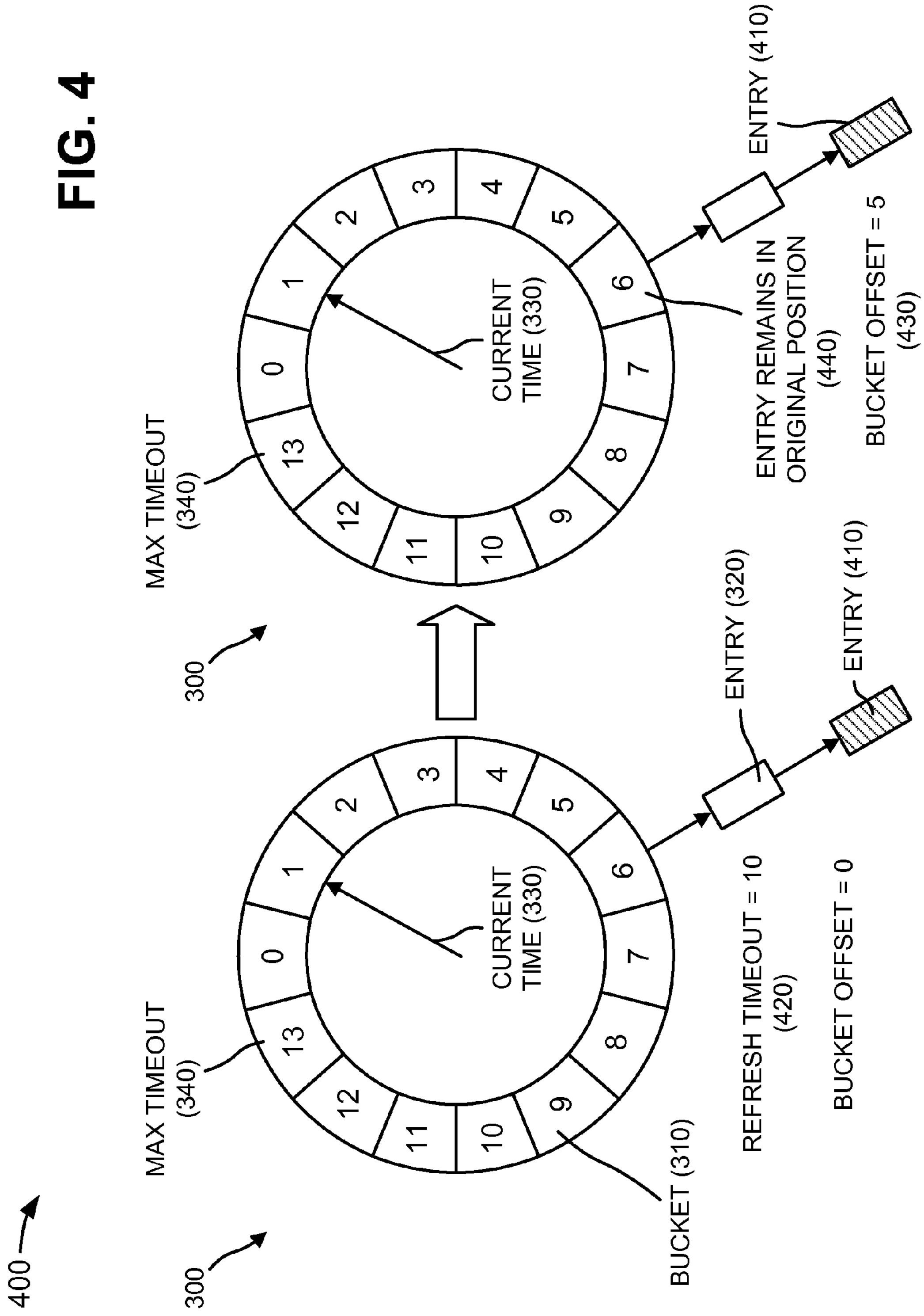

300
MAX TIMEOUT (340)
ENTRY (320)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
CURRENT TIME (330)
BUCKETS (310)
TICK DIRECTION (350)
ENTRY (320)

FIG. 3

FIG. 4


400
300
MAX TIMEOUT (340)
BUCKET (310)
CURRENT TIME (330)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
ENTRY (320)
ENTRY (410)
REFRESH TIMEOUT = 10 (420)
BUCKET OFFSET = 0
300
MAX TIMEOUT (340)
CURRENT TIME (330)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
ENTRY REMAINS IN ORIGINAL POSITION (440)
ENTRY (410)
BUCKET OFFSET = 5 (430)

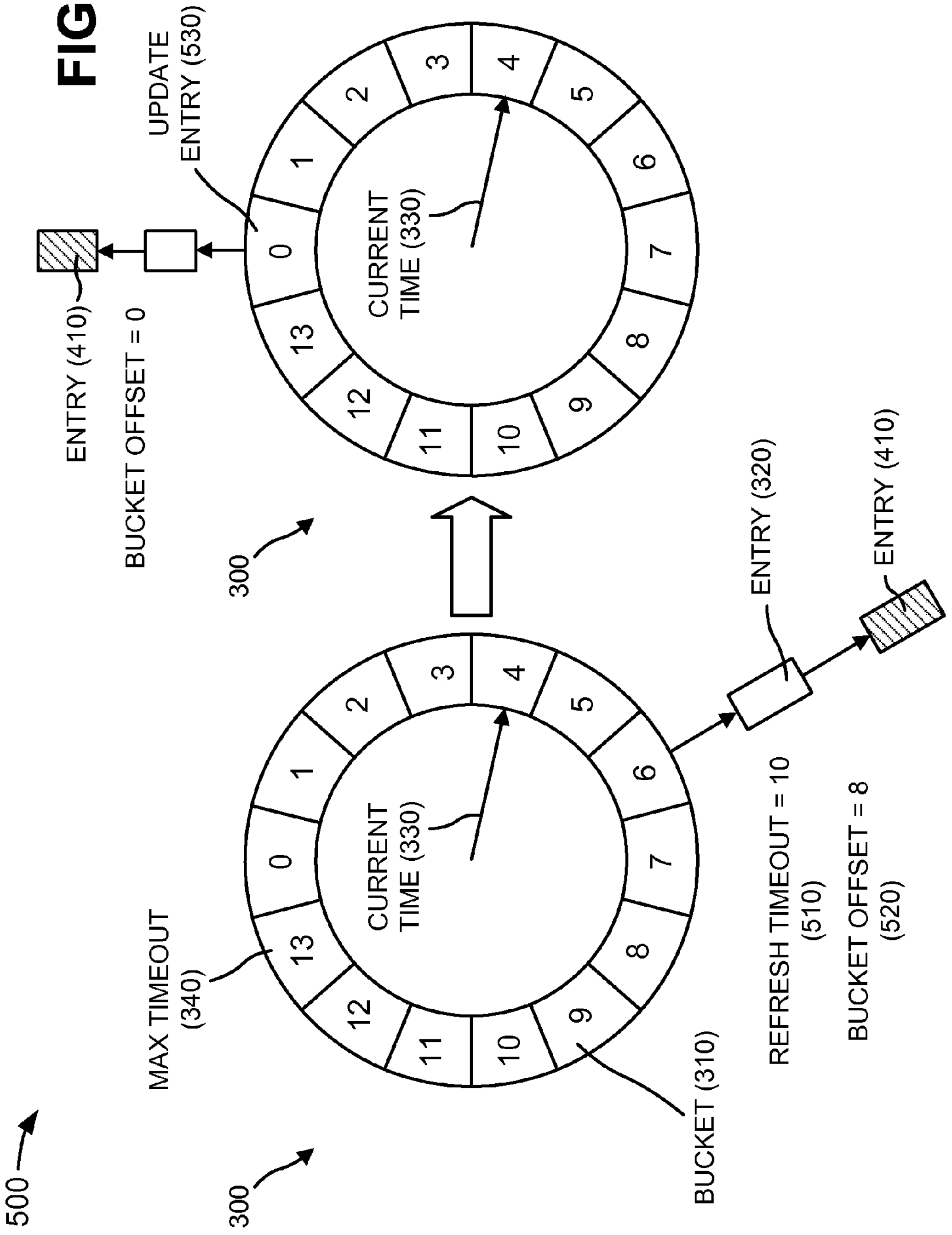

500
300
MAX TIMEOUT (340)
CURRENT TIME (330)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
BUCKET (310)
REFRESH TIMEOUT = 10 (510)
BUCKET OFFSET = 8 (520)
ENTRY (320)
ENTRY (410)
300
ENTRY (410)
BUCKET OFFSET = 0
UPDATE ENTRY (530)
CURRENT TIME (330)
0
1
2
3
4
5
6
7
8
9
10
11
12
13

FIG. 5

FIG. 6

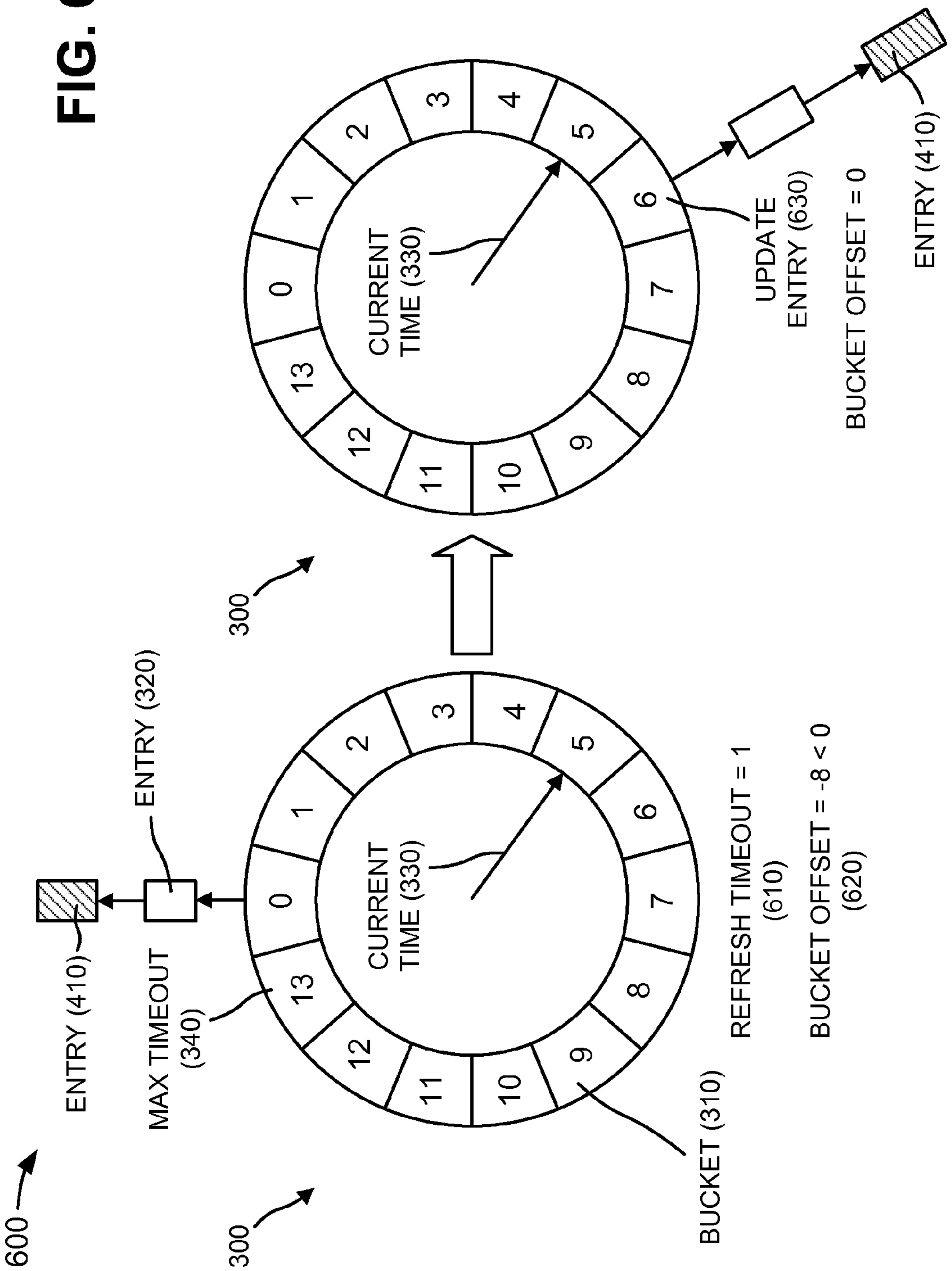
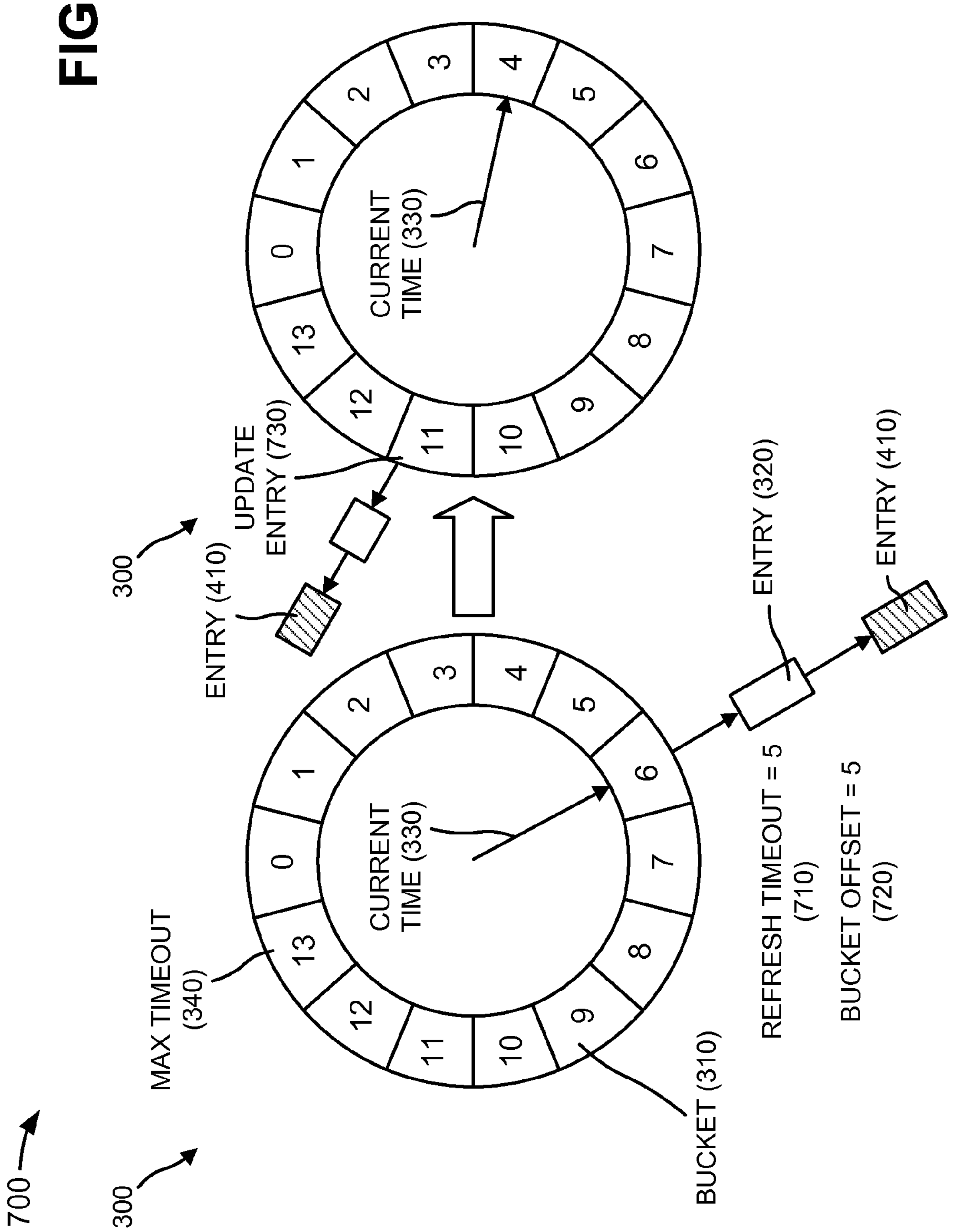

600
300
ENTRY (410)
MAX TIMEOUT (340)
ENTRY (320)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
CURRENT TIME (330)
BUCKET (310)
REFRESH TIMEOUT = 1 (610)
BUCKET OFFSET = -8 < 0 (620)
300
0
1
2
3
4
5
6
7
8
9
10
11
12
13
CURRENT TIME (330)
UPDATE ENTRY (630)
BUCKET OFFSET = 0
ENTRY (410)

FIG. 7


700
300
MAX TIMEOUT (340)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
CURRENT TIME (330)
BUCKET (310)
REFRESH TIMEOUT = 5 (710)
BUCKET OFFSET = 5 (720)
ENTRY (320)
ENTRY (410)
300
ENTRY (410)
UPDATE ENTRY (730)
CURRENT TIME (330)

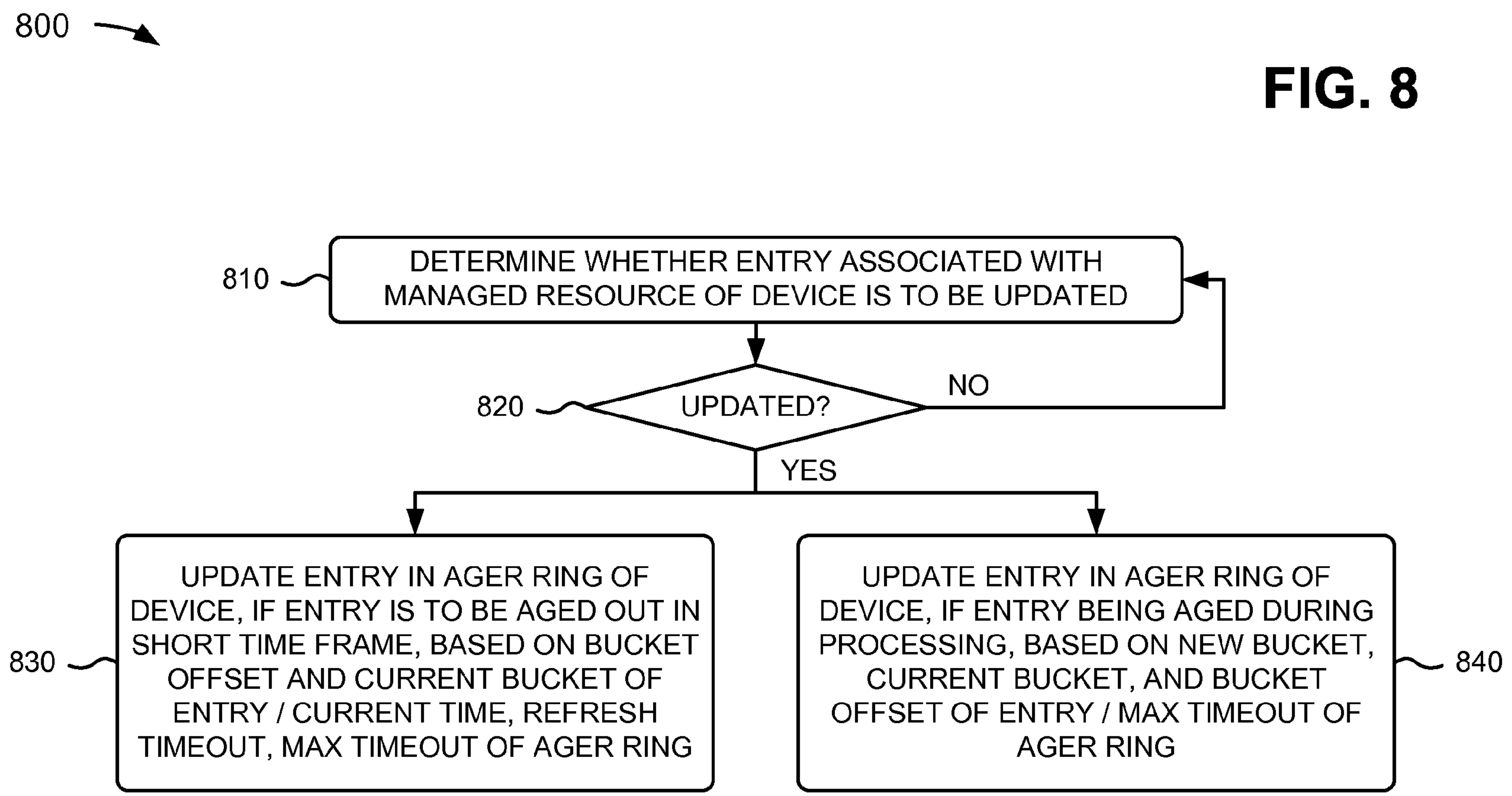

800
810
DETERMINE WHETHER ENTRY ASSOCIATED WITH MANAGED RESOURCE OF DEVICE IS TO BE UPDATED
820
UPDATED?
NO
YES
830
UPDATE ENTRY IN AGER RING OF DEVICE, IF ENTRY IS TO BE AGED OUT IN SHORT TIME FRAME, BASED ON BUCKET OFFSET AND CURRENT BUCKET OF ENTRY / CURRENT TIME, REFRESH TIMEOUT, MAX TIMEOUT OF AGER RING
840
UPDATE ENTRY IN AGER RING OF DEVICE, IF ENTRY BEING AGED DURING PROCESSING, BASED ON NEW BUCKET, CURRENT BUCKET, AND BUCKET OFFSET OF ENTRY / MAX TIMEOUT OF AGER RING

FIG. 8

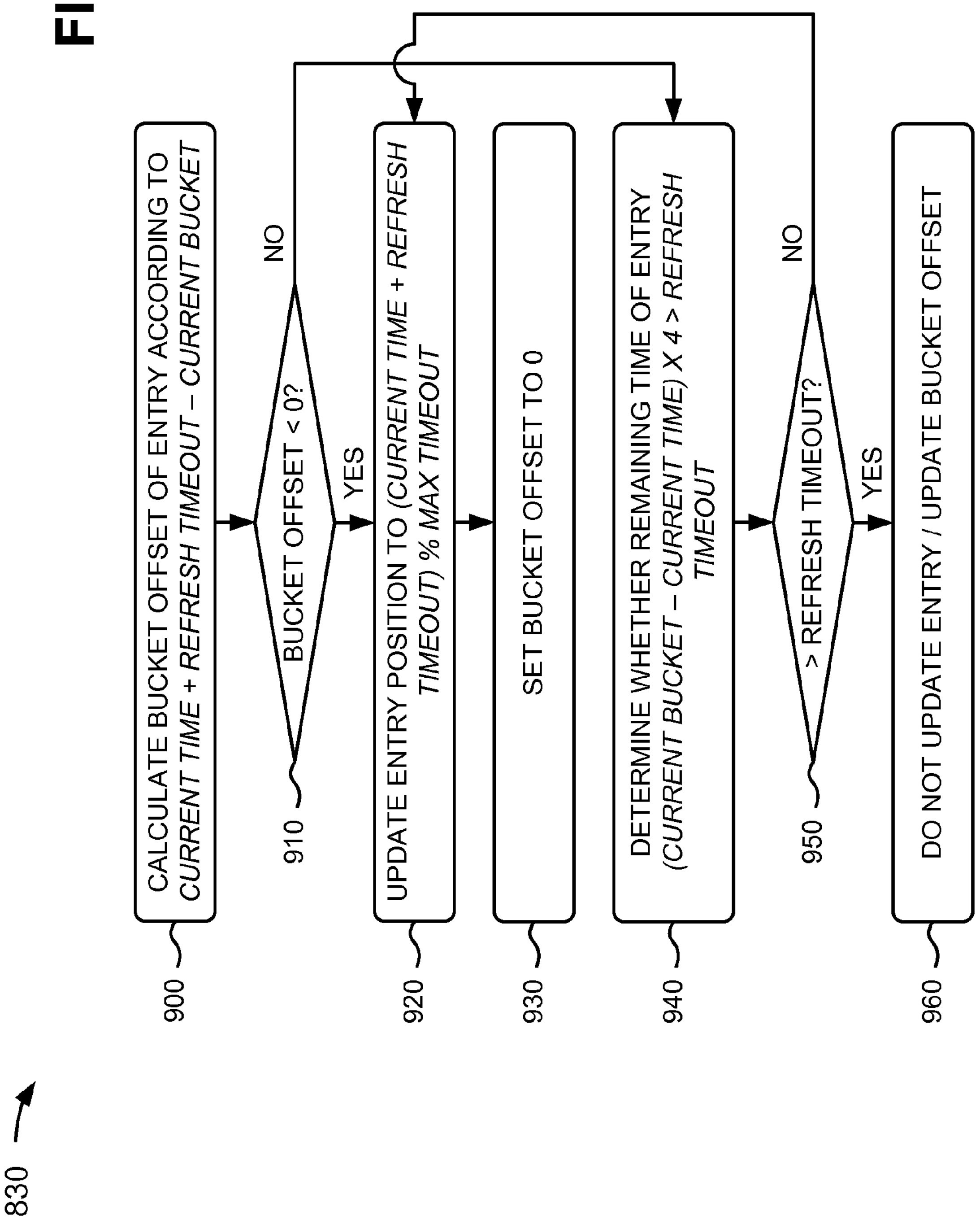
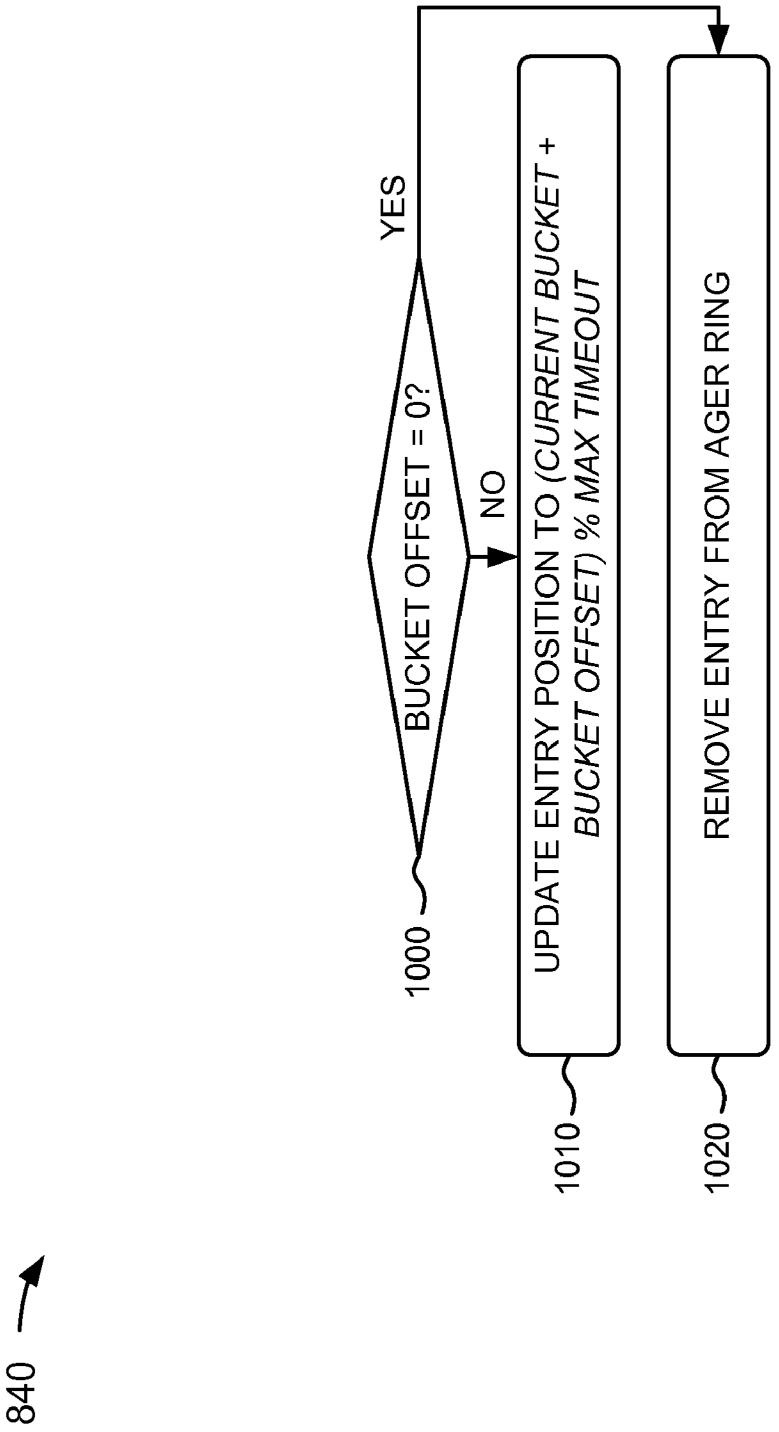

830
900
CALCULATE BUCKET OFFSET OF ENTRY ACCORDING TO *CURRENT TIME + REFRESH TIMEOUT – CURRENT BUCKET*
910
BUCKET OFFSET < 0?
NO
YES
920
UPDATE ENTRY POSITION TO *(CURRENT TIME + REFRESH TIMEOUT) % MAX TIMEOUT*
930
SET BUCKET OFFSET TO 0
940
DETERMINE WHETHER REMAINING TIME OF ENTRY *(CURRENT BUCKET – CURRENT TIME)* X 4 > *REFRESH TIMEOUT*
950
> REFRESH TIMEOUT?
NO
YES
960
DO NOT UPDATE ENTRY / UPDATE BUCKET OFFSET

FIG. 9

FIG. 10


840
1000
BUCKET OFFSET = 0?
YES
NO
1010
UPDATE ENTRY POSITION TO *(CURRENT BUCKET + BUCKET OFFSET) % MAX TIMEOUT*
1020
REMOVE ENTRY FROM AGER RING

AGER RING OPTIMIZATION

BACKGROUND

Computing and communication networks typically include network devices, such as routers, firewalls, switches, servers, or gateways, which transfer or switch data, such as packets, from one or more sources to one or more destinations. Network devices may operate on the packets as the packets traverse the network, such as by forwarding or filtering the packet-based network traffic.

Some network devices (e.g., firewalls) utilize a ring-based aging mechanism (e.g., referred to as an "ager ring") to manage time expirations associated with resources (e.g., firewall sessions). When a time associated with a managed resource expires, the ager ring may delete the managed resource (e.g., delete the firewall session). When the ager ring accelerates a session expiration process, efficient refreshing of the session may be degraded. For example, if a continuous flow of packets are provided during a session, the session may continuously refresh. The ager ring may update the session from one position (e.g., time interval or bucket) of the ager ring to another position of the ager ring, for every packet that is received. For multithread-based network devices, such an arrangement may cause the ager ring to lock old and new positions of the ager ring prior to updating the session.

SUMMARY

According to one aspect, a method may be implemented by a device, and may include determining, by the device, whether an entry associated with a managed resource of the device is to be updated; and updating, by the device and when the entry is to be aged out in a particular time frame, the entry in an ager ring, associated with the device, based on a bucket offset and a current time bucket associated with the entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring.

According to another aspect, a device may include a memory to store a plurality of instructions and an ager ring. The device may also include a processor to execute instructions in the memory to determine whether an entry associated with a managed resource of the device is to be updated, and update, when the entry is to be aged out in a particular time frame, the entry in the ager ring based on a bucket offset and a current time bucket associated with the entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring.

According to still another aspect, a computer-readable memory device may store instructions executable by one or more processors. The computer-readable memory device may include one or more instructions for providing an ager ring that ages one or more entries associated with one or more managed resource of a device, and one or more instructions for determining whether a particular entry associated with a particular managed resource of the device is to be updated. The computer-readable memory device may also include one or more instructions for updating, when the particular entry is to be aged out in a particular time frame, the particular entry in the ager ring based on a bucket offset and a current time bucket associated with the particular entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring. The computer-readable memory device may further include one or more instructions for updating, when the particular entry is being aged during processing, the particular entry in the ager ring based on a new bucket, the current time bucket, and the bucket offset associated with the particular entry and based on the maximum timeout associated with the ager ring.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate one or more implementations described herein and, together with the description, explain these implementations. In the drawings:

FIG. **1** is a diagram of an exemplary network in which systems and/or methods described herein may be implemented;

FIG. **2** is a diagram of exemplary components of a network device depicted in FIG. **1**;

FIG. **3** is a diagram of an exemplary ager ring that may be implemented by the network device depicted in FIG. **1**;

FIG. **4** is a diagram of exemplary operations capable of being performed by the ager ring when an entry of the ager ring is not refreshed;

FIG. **5** is a diagram of exemplary operations capable of being performed by the ager ring when an entry of the ager ring is refreshed;

FIG. **6** is a diagram of exemplary operations capable of being performed by the ager ring when an entry of the ager ring is refreshed due to fast age out;

FIG. **7** is a diagram of exemplary operations capable of being performed by the ager ring when an entry of the ager ring is aged during a refresh; and

FIGS. **8-10** are flow charts of an exemplary process for refreshing entries in an ager ring according to implementations described herein.

DETAILED DESCRIPTION

The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements. Also, the following detailed description does not limit the invention.

Implementations described herein may provide systems and/or methods that update an entry of an ager ring provided in a device, such as a network device. The systems and/or methods may reduce a time associated with an ager ring entry update by updating the entry if the entry is going to be aged out in a short time frame or if the entry is being processed for aging out. In one implementation, for example, the systems and/or methods may determine whether an entry associated a managed resource (e.g., a firewall session) of a device is to be updated. The systems and/or methods may determine that the entry is to be updated when the entry is being refreshed in an ager ring of the device or when the entry is being processed for aging out in the ager ring. If the managed resource is being refreshed, the systems and/or methods may update the entry in the ager ring (e.g., if the entry is to be aged out in a short time frame) based on a variety of parameters associated with the ager ring and/or the entry. If the entry is being aged during processing, the systems and/or methods may update the entry based on additional parameters associated with the ager ring and/or the entry.

Implementations described herein may reduce operations performed by the ager ring when refreshing an entry, especially for managed resources (e.g., such as sessions) where packets drive ager ring updates. For example, if there are one million active sessions and at least one packet every two seconds for each session, current systems would perform one million ager ring updates. However, in the same scenario, implementations described herein may reduce ager ring updates to zero.

The term “managed resource,” as used herein is to be broadly construed to include any resource of a device (e.g., a network device) that may be managed by the device or by an ager ring provided in the device. For example, a managed resource may include a firewall session, an intrusion detection and prevention session, etc.

Exemplary Network

FIG. **1** is a diagram of an exemplary network **100** in which systems and/or methods described herein may be implemented. As illustrated, network **100** may include one or more network devices **110** interconnected by a network **120**. Components of network **100** may interconnect via wired and/or wireless connections or links. Two network devices **110** and a single network **120** have been illustrated in FIG. **1** for simplicity. In practice, there may be more network devices **110** and/or networks **120**. Also, in some instances, one or more of the components of network **100** may perform one or more tasks described as being performed by another one or more of the components of network **100**.

Network device **110** may include a data transfer device, such as a gateway, a router, a switch, a firewall, a network interface card (NIC), a hub, a bridge, a proxy server, an optical add-drop multiplexer (OADM), a server device, or some other type of device that processes and/or transfers traffic. In an exemplary implementation, network device **110** may include a device that is capable of transmitting information to and/or receiving information from other network devices **110** via network **120**.

Network **120** may include one or more networks of any type. For example, network **120** may include a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), a telephone network (such as the Public Switched Telephone Network (PSTN), Public Land Mobile Network (PLMN), a wireless network), an intranet, the Internet, an optical fiber (or fiber optic)-based network, or a combination of networks.

Although FIG. **1** shows exemplary components of network **100**, in other implementations, network **100** may contain fewer components, different components, differently arranged components, or additional components than depicted in FIG. **1**.

Exemplary Network Device Configuration

FIG. **2** illustrates a diagram of exemplary components of a device **200** that may correspond to one of network devices **110**. As shown, device **200** may include a bus **210**, a processing unit **220**, a memory **230**, an input device **240**, an output device **250**, and a communication interface **260**.

Bus **210** may permit communication among the components of device **200**. Processing unit **220** may include one or more processors or microprocessors that interpret and execute instructions. In other implementations, processing unit **220** may be implemented as or include one or more application-specific integrated circuits (ASICs), field-programmable gate arrays (FPGAs), or the like.

Memory **230** may include a random access memory (RAM) or another type of dynamic storage device that stores information and instructions for execution by processing unit **220**, a read only memory (ROM) or another type of static storage device that stores static information and instructions for the processing unit **220**, and/or some other type of magnetic or optical recording medium and its corresponding drive for storing information and/or instructions.

Input device **240** may include a device that permits an operator to input information to device **200**, such as a keyboard, a keypad, a mouse, a pen, a microphone, one or more biometric mechanisms, and the like. Output device **250** may include a device that outputs information to the operator, such as a display, a speaker, etc.

Communication interface **260** may include any transceiver-like mechanism that enables device **200** to communicate with other devices and/or systems. For example, communication interface **360** may include mechanisms for communicating with other devices, such as other network devices **110**.

As described herein, device **200** may perform certain operations in response to processing unit **220** executing software instructions contained in a computer-readable medium, such as memory **230**. A computer-readable medium may be defined as a physical or logical memory device. A logical memory device may include memory space within a single physical memory device or spread across multiple physical memory devices. The software instructions may be read into memory **230** from another computer-readable medium or from another device via communication interface **260**. The software instructions contained in memory **230** may cause processing unit **220** to perform processes described herein. Alternatively, hardwired circuitry may be used in place of or in combination with software instructions to implement processes described herein. Thus, implementations described herein are not limited to any specific combination of hardware circuitry and software.

Although FIG. **2** shows exemplary components of device **200**, in other implementations, device **200** may contain fewer components, different components, differently arranged components, or additional components than depicted in FIG. **2**. Alternatively, or additionally, one or more components of device **200** may perform one or more other tasks described as being performed by one or more other components of device **200**.

Exemplary Ager Ring Configuration/Operations

FIG. **3** is a diagram of an exemplary ager ring **300** that may be implemented by network device **110**. Ager ring **300** may include an age-based mechanism for managing time expirations associated with resources (e.g., firewall sessions) provided by network device **110**. When a time associated with a managed resource expires, ager ring **300** may delete the managed resource (e.g., delete the firewall session). In one implementation, ager ring **300** may be implemented via one or more components of device **200** (FIG. **2**). As shown in FIG. **3**, ager ring **300** may include multiple buckets **310** (e.g., labeled “0” through “13” provided in a clockwise arrangement); one or more entries **320**; a current time **330** associated with ager ring **300**; a maximum (max) timeout **340** associated with ager ring **300**; and a tick direction **350** of ager ring **300**.

Each bucket **310** may represent a time interval (e.g., in seconds, minutes, tens of seconds, etc.) associated with ager ring **300**. Ager ring **300** may include any number of buckets **310**. For example, as shown in FIG. **3**, ager ring **300** may include fourteen (14) buckets **310** labeled “0” to “13” in a clockwise arrangement.

Each entry **320** may include one or more information elements (e.g., packets received during a session) associated with a managed resource (e.g., a firewall session) of network device **110**. The term “packet,” as used herein, is intended to be broadly construed to include a frame, a datagram, a packet, or a cell; a fragment of a frame, a fragment of a datagram, a fragment of a packet, a fragment of a cell; or another type, arrangement, or packaging of data. One or more entries **320** may be associated with a particular bucket **310** of ager ring **300**. For example, as shown in FIG. **3**, one entry **320** may be associated with bucket **310** labeled “1” (e.g., time interval “1”) and another entry **320** may be associated with bucket **310** labeled “6” (e.g., time interval “6”).

Current time **330** may include a current time associated with ager ring **300** (i.e., an “age” of ager ring **300** since its last refresh). For example, as shown in FIG. **3**, current time **330** may be located at time interval “1” (e.g., bucket **310**). Max timeout **340** may include a maximum amount of time before ager ring **300** times out. For example, as shown in FIG. **3**, max timeout **340** may occur at time interval “13” (e.g., bucket **310**). Tick direction **350** may include a direction (e.g., a clockwise direction) that current time **330** moves along ager ring **300**.

In an exemplary implementation, network device **110** may determine whether an entry (e.g., entry **320**) associated with a managed resource (e.g., a firewall session) of network device **110** is to be updated. If entry **320** is not to be updated, network device **110** may wait a particular time period and once again determine whether the entry is to be updated. Network device **110** may determine that entry **320** is to be updated when entry **320** is being refreshed in ager ring **300** (e.g., when entry **320** is going to be aged out in a particular time period) or when entry **320** is being processed for aging out in ager ring **300**.

If entry **320** is being refreshed in ager ring **300** (e.g., packets are being received during a session), network device **110** may calculate a bucket offset of entry **320** according to Equation (1):

$$\text{Bucket Offset}=\text{Current Time}+\text{Refresh Timeout}-\text{Current Bucket}, \tag{1}$$

where “Refresh Timeout” may include a time period until an entry in ager ring **300** is refreshed, and “Current Bucket” may include a particular bucket **310** (e.g., a time value) associated with entry **320**. For example, entries **320** shown in FIG. **3** may be associated with “Current Buckets” (e.g., time values) of “1” and “6.” If “Current Bucket” is less than “Current Time,” network device **110** may determine “Current Bucket” to be the sum of “Current Bucket” and max timeout **340**.

If the “Bucket Offset” calculated in Equation (1) is less than zero (0), network device **110** may update a position of entry **320** in ager ring **300** to a position according to Equation (2), and may set the “Bucket Offset” of entry **320** to zero (0) (e.g., since entry **320** is updated).

$$(\text{Current Time}+\text{Refresh Timeout})\ \%\ \text{Max Timeout}. \tag{2}$$

The “%” sign provided in Equation (2) may include a remainder operator provided in modular arithmetic. Modular arithmetic (e.g., also called “clock arithmetic”) is a system of arithmetic for integers, where numbers wrap around after they reach a certain value or “modulus.” For example, an expression “14% 12” (or 14 (mod 12)) may provide a remainder of “2.”

If the “Bucket Offset” calculated in Equation (1) is greater than or equal to zero (0), network device **110** may use Equation (3) to determine whether a remaining time (e.g., Current Bucket−Current Time) of entry **320** is greater than a particular amount of the “Refresh Timeout.”

$$(\text{Current Bucket}-\text{Current Time})\times 4>\text{Refresh Timeout}. \tag{3}$$

In one example, the number four (4) provided in Equation (3) may be configurable (e.g., by network device **110** or a user of network device **110**). If the remaining time of entry **320** is greater than the “Refresh Timeout,” network device **110** may determine that entry **320** does not need to be updated, and may record the “Bucket Offset” of entry **320**. If the remaining time of entry **320** is less than or equal to the “Refresh Timeout,” network device **110** may proactively update entry **320** according to Equation (2), and may set the “Bucket Offset” of entry **320** to zero (0).

If entry **320** is being processed for aging out in ager ring **300** and the “Bucket Offset” of entry **320** is not equal to zero (0), network device **110** may update a position of entry **320** in ager ring **300** to a position (e.g., a “New Bucket”) calculated according to Equation (4).

$$\text{New Bucket}=(\text{Current Bucket}+\text{Bucket Offset})\ \%\ \text{Max Timeout}. \tag{4}$$

After updating entry **320** to “New Bucket,” network device **110** may set the “Bucket Offset” of entry **320** to zero (0). If entry **320** is being processed for aging out in ager ring **300** and the “Bucket Offset” of entry **320** equals zero (0), network device **110** may remove entry **320** from ager ring **300**.

Although FIG. **3** shows exemplary components of ager ring **300**, in other implementations, ager ring **300** may contain fewer components, different components, differently arranged components, or additional components than depicted in FIG. **3**.

FIG. **4** is a diagram of exemplary operations **400** capable of being performed by ager ring **300** when an entry of ager ring **300** is not refreshed. As shown, ager ring **300** may include buckets **310**, entry **320**, current time **330**, and max timeout **340**. Ager ring **300**, buckets **310**, entry **320**, current time **330**, and max timeout **340** may include the features described above in connection with, for example, FIG. **3**.

As further shown in FIG. **4**, network device **110** may determine whether a particular entry **410** (e.g., provided in bucket **310** labeled “6”) in ager ring **300** is to be updated. Entry **410** may include the features described above for entry **320**. It may further be assumed that ager ring **300** includes a refresh timeout **420** of ten (10) for entry **410** and a max timeout **340** of fourteen (14). Refresh timeout **420** may include a time period until entry **410** in ager ring **300** is refreshed. Since entry **410** is in bucket **310** labeled “6” and current time **330** is “1,” entry **410** may have five (5) ticks (e.g., time intervals) left before entry **410** is deleted (e.g., aged out). Network device **110** may calculate a bucket offset **430** of entry **410** according to Equation (1), and may determine that bucket offset **430** of entry **410** is five (5) based on Equation (1) (i.e., 1+10−6=5).

Since bucket offset **430** is greater than zero, network device **110** may determine whether an update of entry **410** is needed based on Equation (3). Via equation (3), network device **110** may determine that four times the remaining time (e.g., Current Bucket−Current Time) of entry **410** (e.g., (6−1)×4=20) is greater than refresh timeout **420** (e.g., which equals “10”). Therefore, network device **110** may determine that entry **410** does not need to be updated, and may keep entry **410** in its original position (e.g., bucket **310** labeled “6”), as indicated by reference number **440**. Network device **110** may update a bucket offset of entry **410**.

FIG. **5** is a diagram of exemplary operations **500** capable of being performed by ager ring **300** when entry **410** of ager ring **300** is refreshed. As shown, ager ring **300** may include buckets **310**, entry **320**, current time **330**, max timeout **340**, and entry **410**. Ager ring **300**, buckets **310**, entry **320**, current time **330**, max timeout **340**, and entry **410** may include the features described above in connection with, for example, FIGS. **3** and/or **4**.

As further shown in FIG. **5**, current time **330** may have advanced three ticks to bucket **310** labeled "4." Network device **110** may determine whether entry **410** (e.g., provided in bucket **310** labeled "6") in ager ring **300** is to be updated. It may further be assumed that ager ring **300** includes a refresh timeout **510** of ten (10) for entry **410**. Since entry **410** is in bucket **310** labeled "6" and current time **330** is "4," entry **410** may have two (2) ticks (e.g., time intervals) left before entry **410** is deleted (e.g., aged out). Network device **110** may calculate a bucket offset **520** of entry **410** according to Equation (1), and may determine that bucket offset **520** of entry **410** is eight (8) based on Equation (1) (i.e., 4+10−6=8).

Since bucket offset **520** is greater than zero, network device **110** may determine whether an update of entry **410** is needed based on Equation (3). Via equation (3), network device **110** may determine that four times the remaining time (e.g., Current Bucket−Current Time) of entry **410** (e.g., (6−4)×4=8) is not greater than refresh timeout **510** (e.g., which equals "10"). Therefore, network device **110** may determine that entry **410** needs to be updated, and may update the position of entry **410** based on Equation (2) (e.g., where (Current Time+Refresh Timeout) % Max Timeout is (4+10) % 14, which equals zero). Thus, network device **110** may update entry **410** to bucket **310** labeled "0," as indicated by reference number **530**.

FIG. **6** is a diagram of exemplary operations **600** capable of being performed by ager ring **300** when entry **410** of ager ring **300** is refreshed due to fast age out. As shown, ager ring **300** may include buckets **310**, entry **320**, current time **330**, max timeout **340**, and entry **410**. Ager ring **300**, buckets **310**, entry **320**, current time **330**, max timeout **340**, and entry **410** may include the features described above in connection with, for example, FIGS. **3**, **4**, and/or **5**.

As further shown in FIG. **6**, current time **330** may have advanced one tick to bucket **310** labeled "5." It may be assumed that a fast age out of entry **410** will occur (e.g., due to receipt of a reset (RST) command for a session). Network device **110** may determine whether entry **410** (e.g., provided in bucket **310** labeled "0") in ager ring **300** is to be updated. It may further be assumed that ager ring **300** includes a refresh timeout **610** of one (1) for entry **410**. Since entry **410** is in bucket **310** labeled "0" and current time **330** is "5" (i.e., Current Bucket<Current Time), network device **110** may determine "Current Bucket" to be the sum of "Current Bucket" and max timeout **340** (i.e., Current Bucket=0+14=14). Network device **110** may calculate a bucket offset **620** of entry **410** according to Equation (1), and may determine that bucket offset **620** of entry **410** is negative eight (−8) based on Equation (1) (i.e., 5+1−14=−8).

Since bucket offset **620** is less than zero, network device **110** may update the position of entry **410** based on Equation (2) (e.g., where (Current Time+Refresh Timeout) % Max Timeout is (5+1) % 14, which equals six). Thus, network device **110** may update entry **410** to bucket **310** labeled "6," as indicated by reference number **630**. Network device **110** may set the bucket offset of entry **410** to zero (0) since entry **410** has been updated.

FIG. **7** is a diagram of exemplary operations **700** capable of being performed by ager ring **300** when entry **410** of ager ring **300** is aged during a refresh. As shown, ager ring **300** may include buckets **310**, entry **320**, current time **330**, max timeout **340**, and entry **410**. Ager ring **300**, buckets **310**, entry **320**, current time **330**, max timeout **340**, and entry **410** may include the features described above in connection with, for example, FIGS. **3**, **4**, **5**, and/or **6**.

As further shown in FIG. **7**, both entry **410** and current time **330** may be associated with bucket **310** labeled "6." Network device **110** may determine whether entry **410** in ager ring **300** is to be updated. It may further be assumed that ager ring **300** includes a refresh timeout **710** of five (5) for entry **410**. Since entry **410** is in bucket **310** labeled "6" and current time **330** is "6," network device **110** may calculate a bucket offset **720** of entry **410** according to Equation (1), and may determine that bucket offset **720** of entry **410** is five (5) based on Equation (1) (i.e., 6+5−6=5).

Since bucket offset **720** is not zero and entry **410** is being aged, network device **110** may update the position of entry **410** based on Equation (4) (e.g., where (Current Time+Bucket Offset) % Max Timeout is (6+5) % 14, which equals eleven). Thus, network device **110** may update entry **410** to bucket **310** labeled "11," as indicated by reference number **730**.

Although FIGS. **4-7** show exemplary operations capable of being performed by ager ring **300**, in other implementations, ager ring **300** may perform different operations or additional operations than depicted in FIGS. **4-7**.

Exemplary Process

FIGS. **8-10** are flow charts of an exemplary process **800** for refreshing entries in an ager ring according to implementations described herein. In one implementation, process **800** may be performed by network device **110**. In another implementation, some or all of process **800** may be performed by ager ring **300** of network device **110**.

As illustrated in FIG. **8**, process **800** may include determining whether an entry associated with a managed resource of a device is to be updated (block **810**). If the entry is not to be updated (block **820**—NO), process **800** may return to process block **810**. For example, in implementations described above in connection with FIG. **3**, network device **110** may determine whether an entry (e.g., entry **320**) associated with a managed resource (e.g., a firewall session) of network device **110** is to be updated. If entry **320** is not to be updated, network device **110** may wait a particular time period and once again determine whether the entry is to be updated.

As further shown in FIG. **8**, if the entry is to be updated (block **820**—YES), process **800** may include updating the entry in an ager ring of the device, if the entry is to be aged out in a short time frame, based on a bucket offset and a current bucket of the entry and based on a current time, a refresh timeout, and a max timeout of the ager ring (block **830**). For example, in implementations described above in connection with FIG. **3**, network device **110** may determine that entry **320** is to be updated when entry **320** is being refreshed in ager ring **300** (e.g., when entry **320** is going to be aged out in a particular time period). Network device **110** may update entry **320** based on a variety of parameters, such as a bucket offset and a current bucket associated with entry **320**, and/or current time **330**, a refresh timeout, and max timeout **340** associated with ager ring **300**.

Returning to FIG. **8**, if the entry is to be updated (block **820**—YES), process **800** may, alternatively, include updating the entry in the ager ring of the device, if the entry is being aged during processing, based on a new bucket, the bucket offset, and the current bucket of the entry and based on the max timeout of the ager ring (block **840**). For example, in implementations described above in connection with FIG. **3**, network device **110** may determine that entry **320** is to be updated when entry **320** is being processed for aging out in ager ring **300**. Network device **110** may update entry **320** based on a variety of parameters, such as a new bucket, a bucket offset, and a current bucket associated with entry **320**, and/or max timeout **340** associated with ager ring **300**.

Process block **830** may include the process blocks depicted in FIG. **9**. As shown in FIG. **9**, process block **830** may include calculating the bucket offset of the entry according to Current Time+Refresh Timeout−Current Bucket (block **900**). If the bucket offset is less than zero (block **910**—YES), process block **830** may include updating the entry position to (Current Time+Refresh Timeout) % Max Timeout (block **920**), and setting the bucket offset to zero (block **930**). For example, in implementations described above in connection with FIG. **3**, if entry **320** is being refreshed in ager ring **300**, network device **110** may calculate a bucket offset of entry **320** according to Equation (1): Bucket Offset=Current Time+Refresh Timeout−Current Bucket. If the "Bucket Offset" calculated in Equation (1) is less than zero (0), network device **110** may update a position of entry **320** in ager ring **300** to a position according to Equation (2): (Current Time+Refresh Timeout) % Max Timeout, and may set the "Bucket Offset" of entry **320** to zero (0) (e.g., since entry **320** is updated).

As further shown in FIG. **9**, if the bucket offset is greater than or equal to zero (block **910**—NO), process block **830** may include determining whether four times a remaining time of entry (Current Bucket−Current Time) is greater than the refresh timeout (block **940**). If four times the remaining time of entry is greater than the refresh timeout (block **950**—YES), the entry may not be updated but the bucket offset of the entry may be updated (block **960**). Otherwise (block **950**—NO), process block **830** may return to process block **920**. For example, in implementations described above in connection with FIG. **3**, if the "Bucket Offset" calculated in Equation (1) is greater than or equal to zero (0), network device **110** may use Equation (3): (Current Bucket−Current Time)×4>Refresh Timeout to determine whether four times a remaining time (e.g., Current Bucket−Current Time) of entry **320** is greater than a particular amount of the "Refresh Timeout." If four times the remaining time of entry **320** is greater than the "Refresh Timeout," network device **110** may determine that entry **320** does not need to be updated, may update the "Bucket Offset" of entry **320**, and may record the "Bucket Offset" of entry **320**. If the remaining time of entry **320** is less than or equal to the "Refresh Timeout," network device **110** may proactively update entry **320** according to Equation (2), and may set the "Bucket Offset" of entry **320** to zero (0).

Process block **840** may include the process blocks depicted in FIG. **10**. As shown in FIG. **10**, process block **840** may include determining whether the bucket offset is equal to zero (block **1000**). If the bucket offset does not equal zero (block **1000**—NO), process block **840** may include updating the entry position to (Current Bucket+Bucket Offset) % Max Timeout (block **1010**). If the bucket offset equals zero (block **1000**—YES), the entry may be removed from the ager ring (block **1020**). For example, in implementations described above in connection with FIG. **3**, if entry **320** is being processed for aging out in ager ring **300** and the "Bucket Offset" of entry **320** is not equal to zero (0), network device **110** may update a position of entry **320** in ager ring **300** to a position (e.g., a "New Bucket") calculated according to Equation (4): New Bucket=(Current Bucket+Bucket Offset) % Max Timeout. After updating entry **320** to "New Bucket," network device **110** may set the "Bucket Offset" of entry **320** to zero (0). If entry **320** is being processed for aging out in ager ring **300** and the "Bucket Offset" of entry **320** equals zero (0), network device **110** may remove entry **320** from ager ring **300**.

CONCLUSION

Implementations described herein may provide systems and/or methods that update an entry of an ager ring provided in a device, such as a network device. The systems and/or methods may reduce a time associated with an ager ring entry update by updating the entry if the entry is going to be aged out in a short time frame or if the entry is being processed for aging out. In one implementation, for example, the systems and/or methods may determine whether an entry associated a managed resource (e.g., a firewall session) of a device is to be updated. The systems and/or methods may determine that the entry is to be updated when the entry is being refreshed in an ager ring of the device or when the entry is being processed for aging out in the ager ring. If the managed resource is being refreshed, the systems and/or methods may update the entry in the ager ring based on a variety of parameters associated with the ager ring and/or the entry. If the entry is being aged during processing, the systems and/or methods may update the entry based on additional parameters associated with the ager ring and/or the entry.

The foregoing description of implementations provides illustration and description, but is not intended to be exhaustive or to limit the invention to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention.

For example, while series of blocks have been described with regard to FIGS. **8-10**, the order of the blocks may be modified in other implementations. Further, non-dependent blocks may be performed in parallel.

It will be apparent that exemplary aspects, as described above, may be implemented in many different forms of software, firmware, and hardware in the embodiments illustrated in the figures. The actual software code or specialized control hardware used to implement these aspects should not be construed as limiting. Thus, the operation and behavior of the aspects were described without reference to the specific software code—it being understood that software and control hardware could be designed to implement the aspects based on the description herein.

Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the invention. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification.

No element, act, or instruction used in the present application should be construed as critical or essential to the invention unless explicitly described as such. Also, as used herein, the article "a" is intended to include one or more items. Where only one item is intended, the term "one" or similar language is used. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

What is claimed is:

1. A method implemented by a device, the method comprising:

determining, by the device, whether an entry associated with a managed resource of the device is to be updated; and

updating, by the device and when the entry is to be aged out in a particular time frame, the entry in an ager ring, associated with the device, based on a bucket offset and a current time bucket associated with the entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring,

where the bucket offset of the entry is calculated according to the following:

Current Time +Refresh Timeout −Current Bucket, and

where the Current Time and the Refresh Timeout correspond to the current time and the refresh timeout associated with the ager ring, respectively, and where the Current Bucket corresponds to the current time bucket associated with the entry.

2. The method of claim 1, where updating the entry further comprises:

updating a position of the entry in the ager ring, when the calculated bucket offset is less than zero, according to the following:

$$(\text{Current Time} + \text{Refresh Timeout}) \% \text{ Max Timeout},$$

where the Max Timeout corresponds to the maximum timeout associated with the ager ring; and

setting the bucket offset to zero after updating the position of the entry.

3. The method of claim 1, where updating the entry further comprises:

determining whether a remaining time of the entry is greater than the refresh timeout, according to the following:

$$(\text{Current Bucket} - \text{Current Time}) \times 4 > \text{Refresh Timeout},$$

where (Current Bucket −Current Time) corresponds to the remaining time of the entry.

4. The method of claim 3, where updating the entry further comprises:

preventing the entry from being updated when four times the remaining time of the entry is greater than the refresh timeout.

5. The method of claim 3, where updating the entry further comprises:

updating a position of the entry in the ager ring, when four times the remaining time of the entry is less than or equal to the refresh timeout, according to the following:

$$(\text{Current Time} + \text{Refresh Timeout}) \% \text{ Max Timeout},$$

where the Max Timeout corresponds to the maximum timeout associated with the ager ring; and

setting the bucket offset to zero after updating the position of the entry.

6. The method of claim 1, further comprising:

updating the entry in the ager ring of the device, when the entry is being aged during processing, based on a new bucket, the current time bucket, and the bucket offset associated with the entry and based on the maximum timeout associated with the ager ring.

7. The method of claim 6, where updating the entry in the ager ring of the device, when the entry is being aged during processing, further comprises:

determining whether the bucket offset equals zero; and

updating a position of the entry in the ager ring, when the bucket offset does not equal zero, according to the following:

$$(\text{Current Bucket} + \text{Bucket Offset}) \% \text{ Max Timeout},$$

where the Current Bucket and the Bucket Offset correspond to the current time bucket and the bucket offset associated with the entry, respectively, and where the Max Timeout corresponds to the maximum timeout associated with the ager ring.

8. The method of claim 7, where updating the entry in the ager ring of the device, when the entry is being aged during processing, further comprises:

removing the entry from the ager ring when the bucket offset equals zero.

9. The method of claim 1, where the devices comprises at least one of:

a gateway,

a router,

a switch,

a firewall,

a network interface card (NIC),

a hub,

a bridge,

a server,

a proxy server, or

an optical add-drop multiplexer (OADM).

10. A device, comprising:

a memory to:

store a plurality of instructions, and

store an ager ring; and

a processor to execute instructions in the memory to:

determine whether an entry associated with a managed resource of the device is to be updated, and

update, when the entry is to be aged out in a particular time frame, the entry in the ager ring based on a bucket offset and a current time bucket associated with the entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring,

where the bucket offset of the entry is calculated according to the following:

$$\text{Current Time} + \text{Refresh Timeout} - \text{Current Bucket, and}$$

where the Current Time and the Refresh Timeout correspond to the current time and the refresh timeout associated with the ager ring, respectively, and where the Current Bucket corresponds to the current time bucket associated with the entry.

11. The device of claim 10, where, when updating the entry, the processor is further to execute instructions in the memory to:

update a position of the entry in the ager ring, when the calculated bucket offset is less than zero, according to the following:

$$(\text{Current Time} + \text{Refresh Timeout}) \% \text{ Max Timeout},$$

where the Max Timeout corresponds to the maximum timeout associated with the ager ring, and

set the bucket offset to zero after updating the position of the entry.

12. The device of claim 10, where, when updating the entry, the processor is further to execute instructions in the memory to:

determine whether a remaining time of the entry is greater than the refresh timeout, according to the following:

$$(\text{Current Bucket} - \text{Current Time}) \times 4 > \text{Refresh Timeout},$$

where (Current Bucket Current Time) corresponds to the remaining time of the entry.

13. The device of claim 12, where, when updating the entry, the processor is further to execute instructions in the memory to:

prevent the entry from being updated when four times the remaining time of the entry is greater than the refresh timeout.

14. The device of claim 12, where, when updating the entry, the processor is further to execute instructions in the memory to:

update a position of the entry in the ager ring, when four times the remaining time of the entry is less than or equal to the refresh timeout, according to the following:

$$(\text{Current Time} + \text{Refresh Timeout}) \% \text{ Max Timeout},$$

where the Max Timeout corresponds to the maximum timeout associated with the ager ring, and set the bucket offset to zero after updating the position of the entry.

15. The device of claim **10**, where the processor is further to execute instructions in the memory to:

update, when the entry is being aged during processing, the entry in the ager ring based on a new bucket, the current time bucket, and the bucket offset associated with the entry and based on the maximum timeout associated with the ager ring.

16. The device of claim **15**, where, when updating the entry in the ager ring, when the entry is being aged during processing, the processor is further to execute instructions in the memory to:

determine whether the bucket offset equals zero,

update a position of the entry in the ager ring, when the bucket offset does not equal zero, according to the following:

(Current Bucket +Bucket Offset) % Max Timeout,

where the Current Bucket and the Bucket Offset correspond to the current time bucket and the bucket offset associated with the entry, respectively, and where the Max Timeout corresponds to the maximum timeout associated with the ager ring, and

remove the entry from the ager ring when the bucket offset equals zero.

17. The device of claim **10**, where the device comprises one or more of:

a gateway,
a router,
a switch,
a firewall,
a network interface card (NIC),
a hub,

a bridge,
a proxy server, or
an optical add-drop multiplexer (OADM).

18. A computer-readable memory device, comprising:

one or more instructions that, when executed by a processor of a device, cause the processor to:

provide an ager ring that ages one or more entries associated with one or more managed resource of a device;

determine whether a particular entry associated with a particular managed resource of the device is to be updated;

update, when the particular entry is to be aged out in a particular time frame, the particular entry in the ager ring based on a bucket offset and a current time bucket associated with the particular entry and based on a current time, a refresh timeout, and a maximum timeout associated with the ager ring,

where the bucket offset of the particular entry is calculated according to the following:

Current Time +Refresh Timeout −Current Bucket, and

where the Current Time and the Refresh Timeout correspond to the current time and the refresh timeout associated with the ager ring, respectively, and where the Current Bucket corresponds to the current time bucket associated with the entry; and

update, when the particular entry is being aged during processing, the particular entry in the ager ring based on a new bucket, the current time bucket, and the bucket offset associated with the particular entry and based on the maximum timeout associated with the ager ring.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

Page 1 of 1

PATENT NO.	: 8,140,656 B2
APPLICATION NO.	: 12/732268
DATED	: March 20, 2012
INVENTOR(S)	: Tian Chen et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 12, claim 12, line 50, change (Current Bucket Current Time) to read --(Current Bucket - Current Time)--.

Signed and Sealed this
First Day of May, 2012

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office