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(54) **METHODS, SYSTEMS AND COMPUTER PROGRAM PRODUCTS FOR THERMAL MANAGEMENT OF A PROCESSOR ASSOCIATED WITH A NETWORK INTERFACE**

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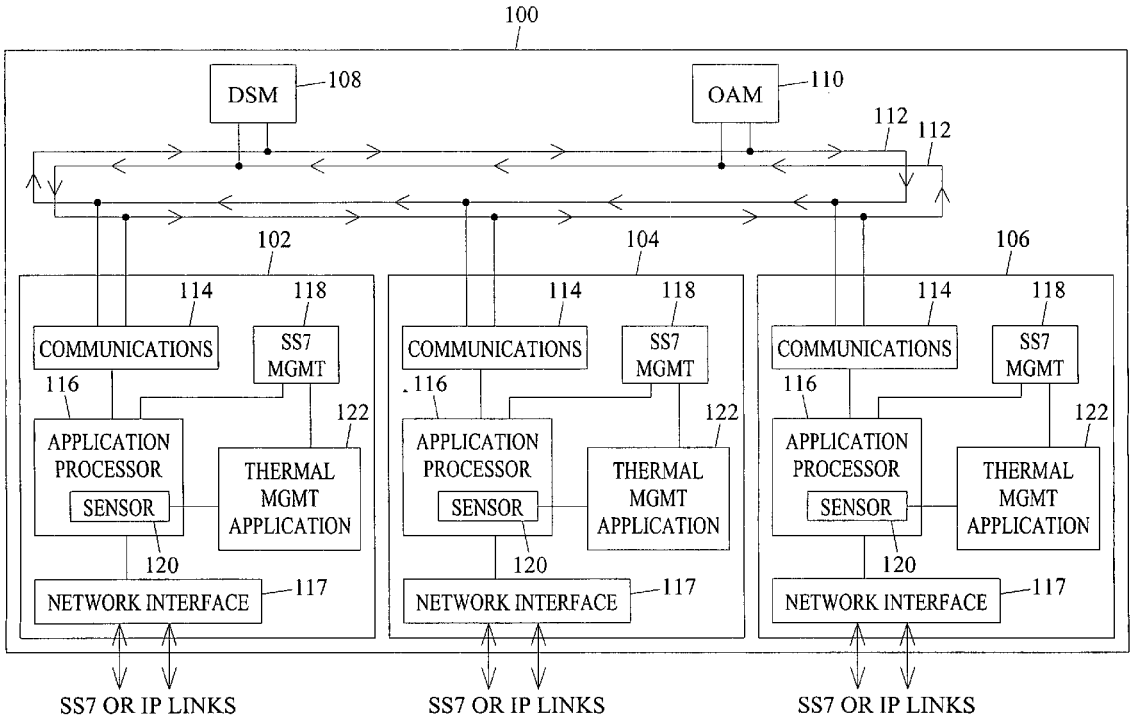
(57) **ABSTRACT**

Methods, systems, and computer program products for thermal management of a processor associated with a network interface are disclosed. According to one method, message traffic is sent and received using a first processor associated with a first network interface. A temperature associated with the first processor is determined. Message traffic is switched from the first processor to a second processor in response to the temperature associated with the first processor having a predetermined relationship with respect to a threshold value. The threshold value can be less than a thermal shutdown level of the first processor.



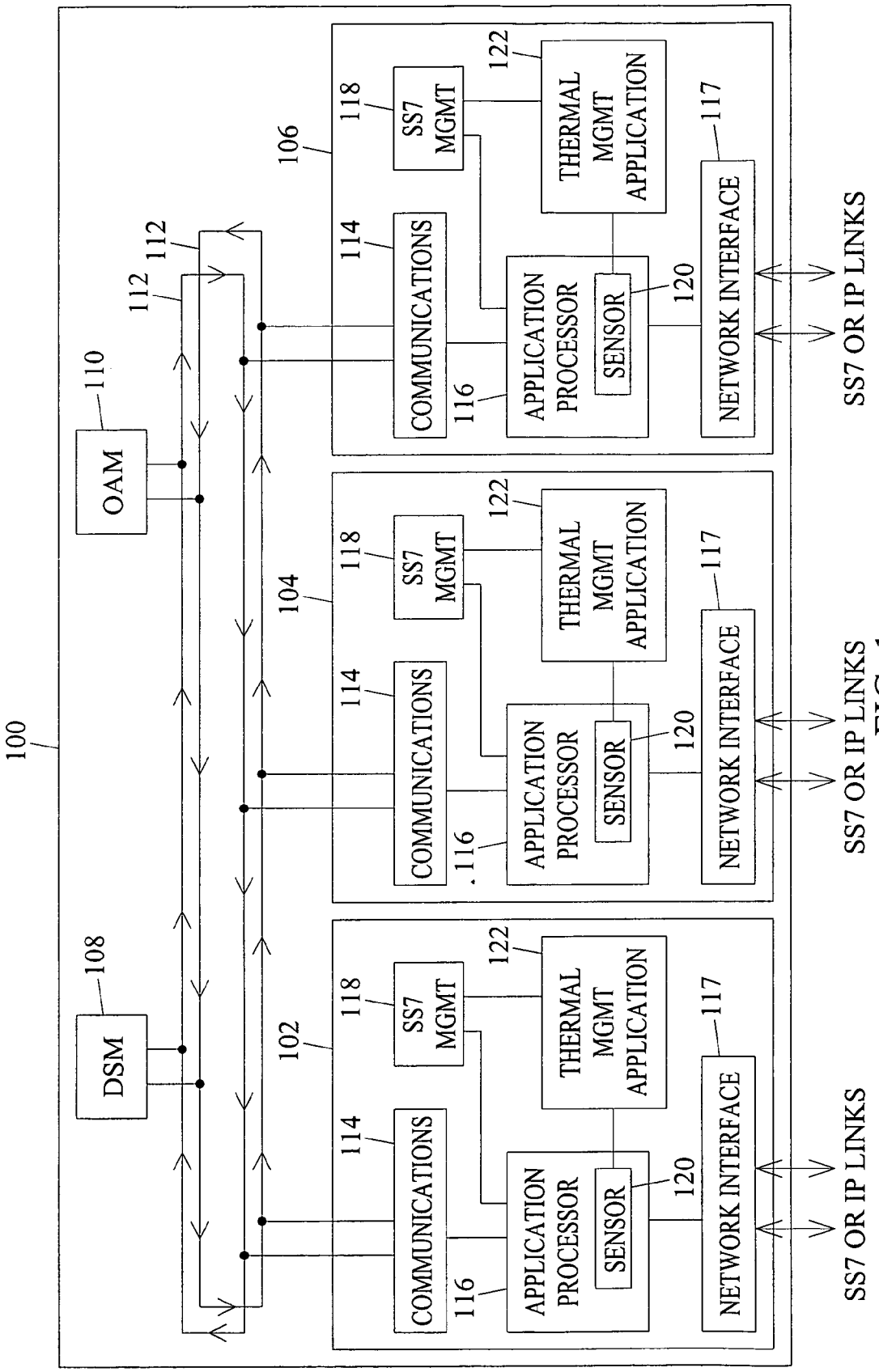

100
102
104
106
108
DSM
110
OAM
112
112
114
COMMUNICATIONS
116
APPLICATION PROCESSOR
SENSOR
118
SS7 MGMT
120
122
THERMAL MGMT APPLICATION
117
NETWORK INTERFACE
SS7 OR IP LINKS
SS7 OR IP LINKS
SS7 OR IP LINKS

FIG. 1

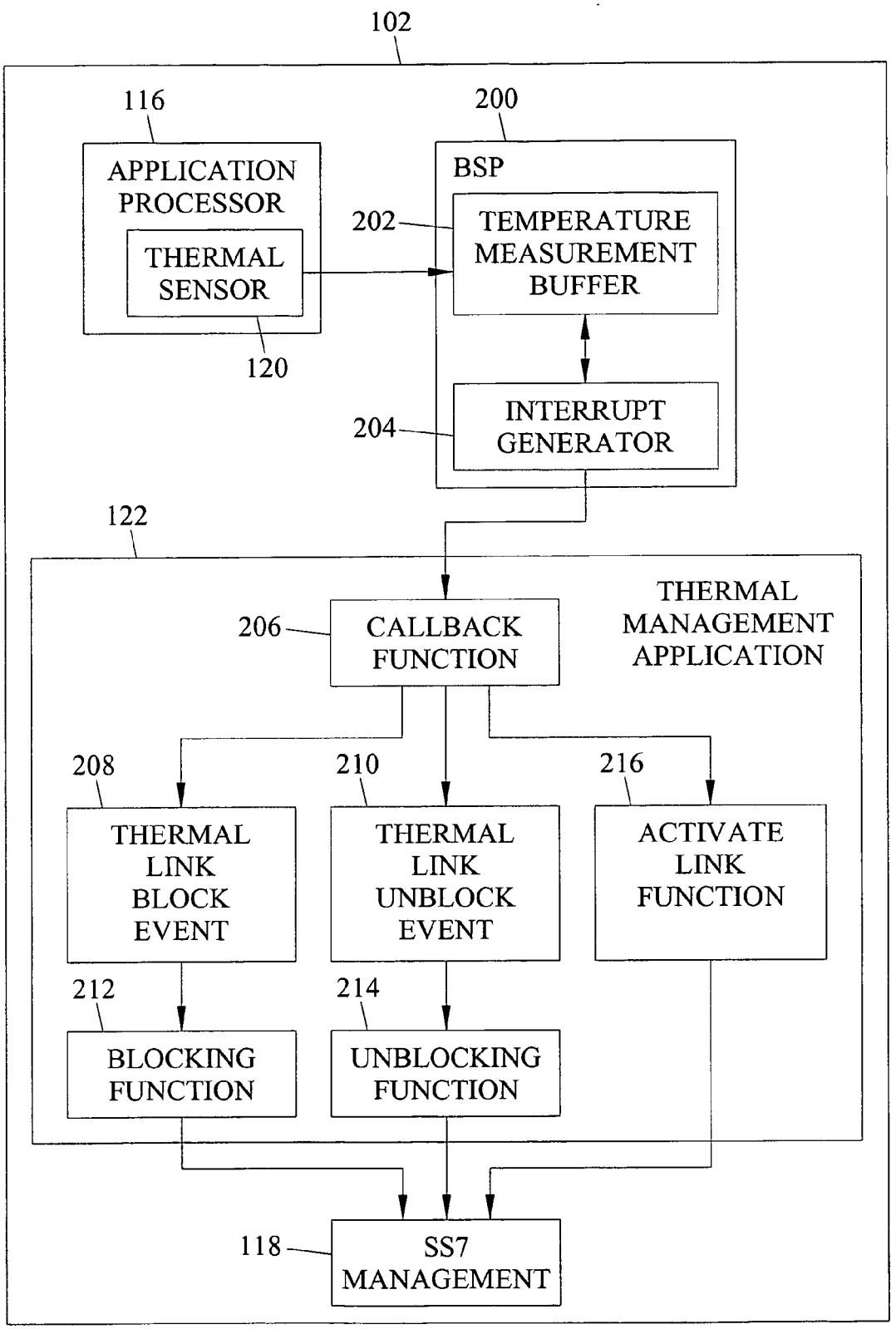

102
116
APPLICATION PROCESSOR
THERMAL SENSOR
120
200
BSP
202
TEMPERATURE MEASUREMENT BUFFER
204
INTERRUPT GENERATOR
122
THERMAL MANAGEMENT APPLICATION
206
CALLBACK FUNCTION
208
THERMAL LINK BLOCK EVENT
210
THERMAL LINK UNBLOCK EVENT
216
ACTIVATE LINK FUNCTION
212
BLOCKING FUNCTION
214
UNBLOCKING FUNCTION
118
SS7 MANAGEMENT

FIG. 2

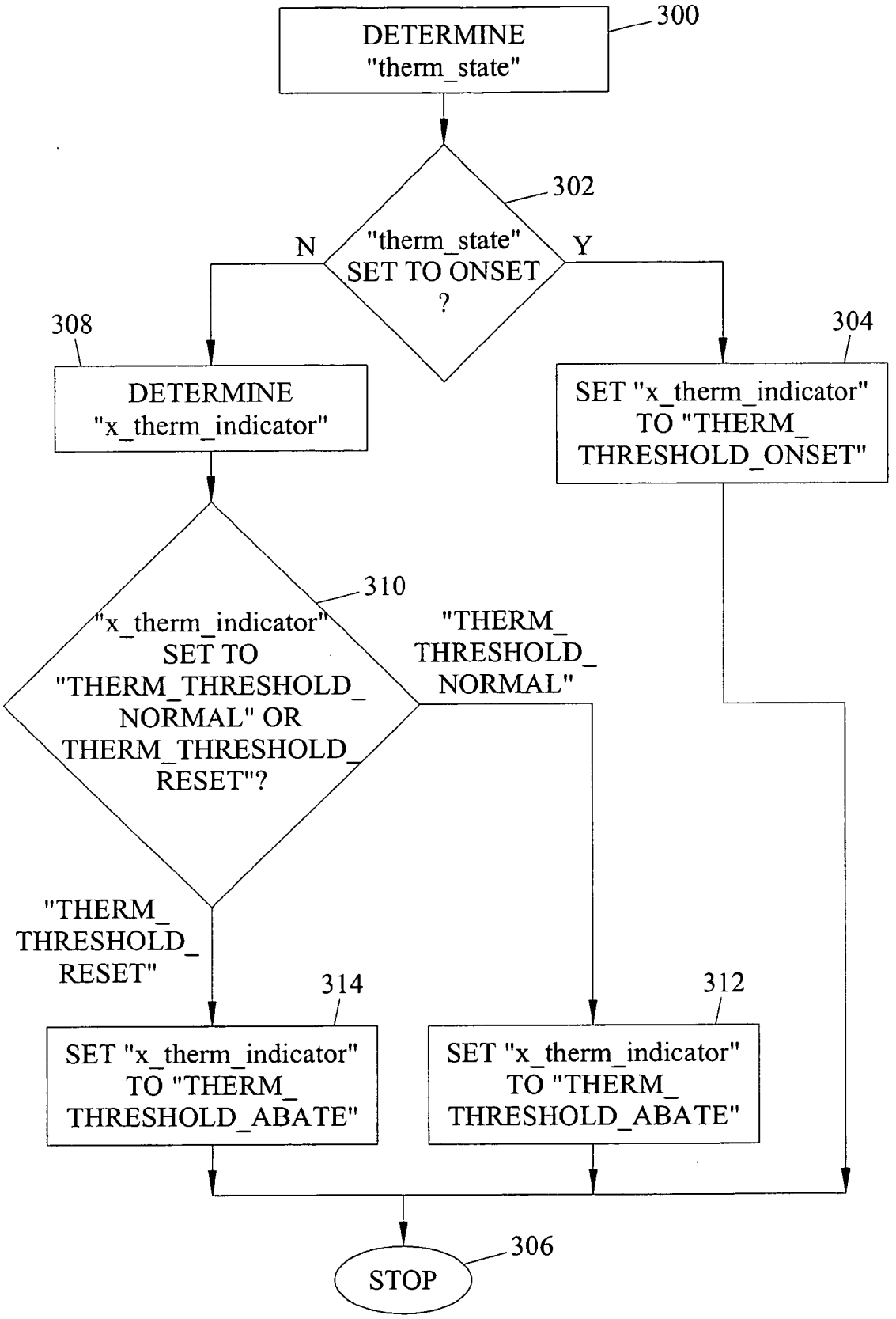

DETERMINE "therm_state"
300
"therm_state" SET TO ONSET ?
302
N
Y
308
DETERMINE "x_therm_indicator"
304
SET "x_therm_indicator" TO "THERM_ THRESHOLD_ONSET"
"x_therm_indicator" SET TO "THERM_THRESHOLD_ NORMAL" OR THERM_THRESHOLD_ RESET"?
310
"THERM_ THRESHOLD_ NORMAL"
"THERM_ THRESHOLD_ RESET"
314
SET "x_therm_indicator" TO "THERM_ THRESHOLD_ABATE"
312
SET "x_therm_indicator" TO "THERM_ THRESHOLD_ABATE"
STOP
306

FIG. 3

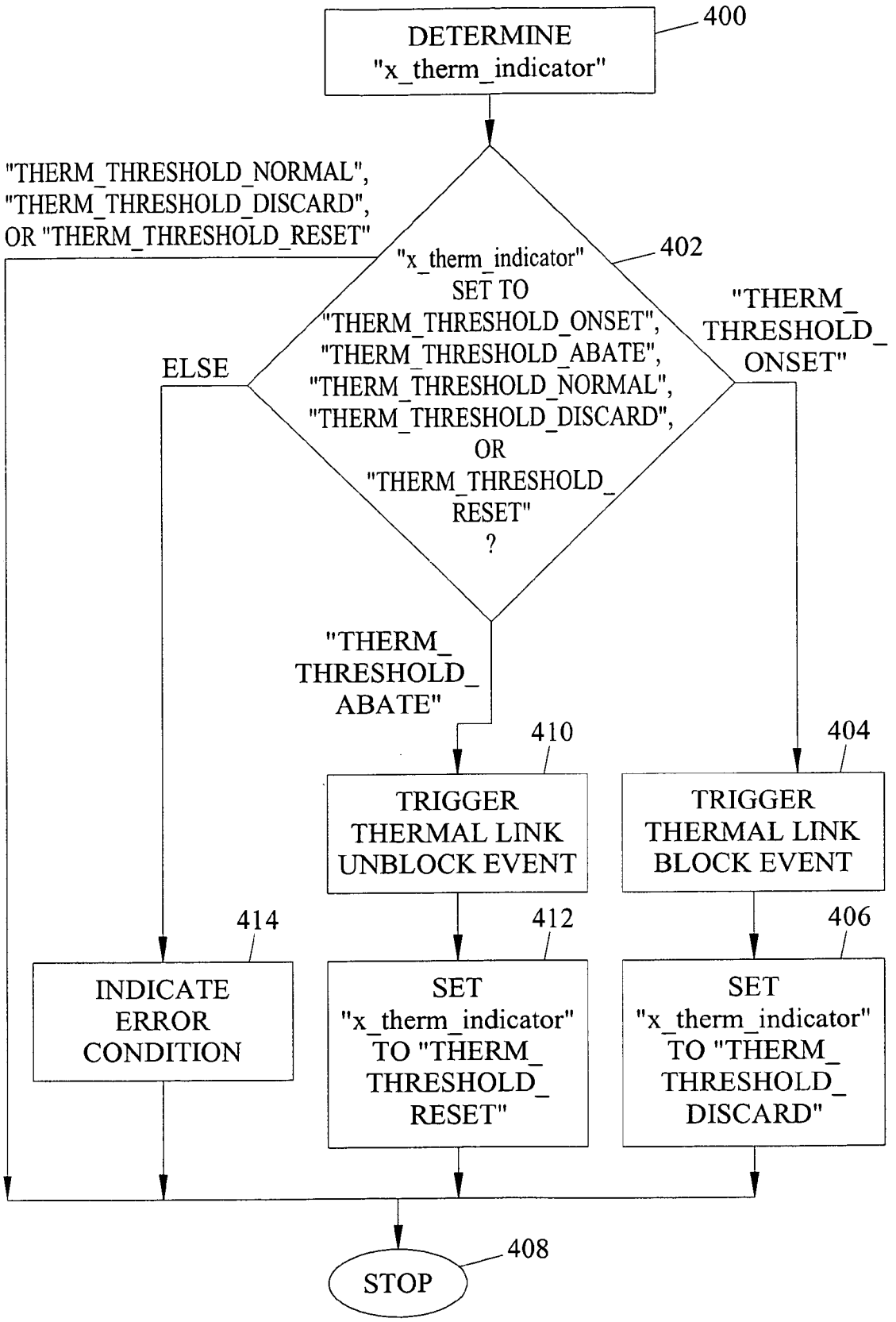

DETERMINE "x_therm_indicator"
400
"x_therm_indicator" SET TO "THERM_THRESHOLD_ONSET", "THERM_THRESHOLD_ABATE", "THERM_THRESHOLD_NORMAL", "THERM_THRESHOLD_DISCARD", OR "THERM_THRESHOLD_RESET" ?
402
"THERM_THRESHOLD_NORMAL", "THERM_THRESHOLD_DISCARD", OR "THERM_THRESHOLD_RESET"
ELSE
"THERM_THRESHOLD_ONSET"
"THERM_THRESHOLD_ABATE"
TRIGGER THERMAL LINK UNBLOCK EVENT
410
TRIGGER THERMAL LINK BLOCK EVENT
404
INDICATE ERROR CONDITION
414
SET "x_therm_indicator" TO "THERM_THRESHOLD_RESET"
412
SET "x_therm_indicator" TO "THERM_THRESHOLD_DISCARD"
406
STOP
408

FIG. 4

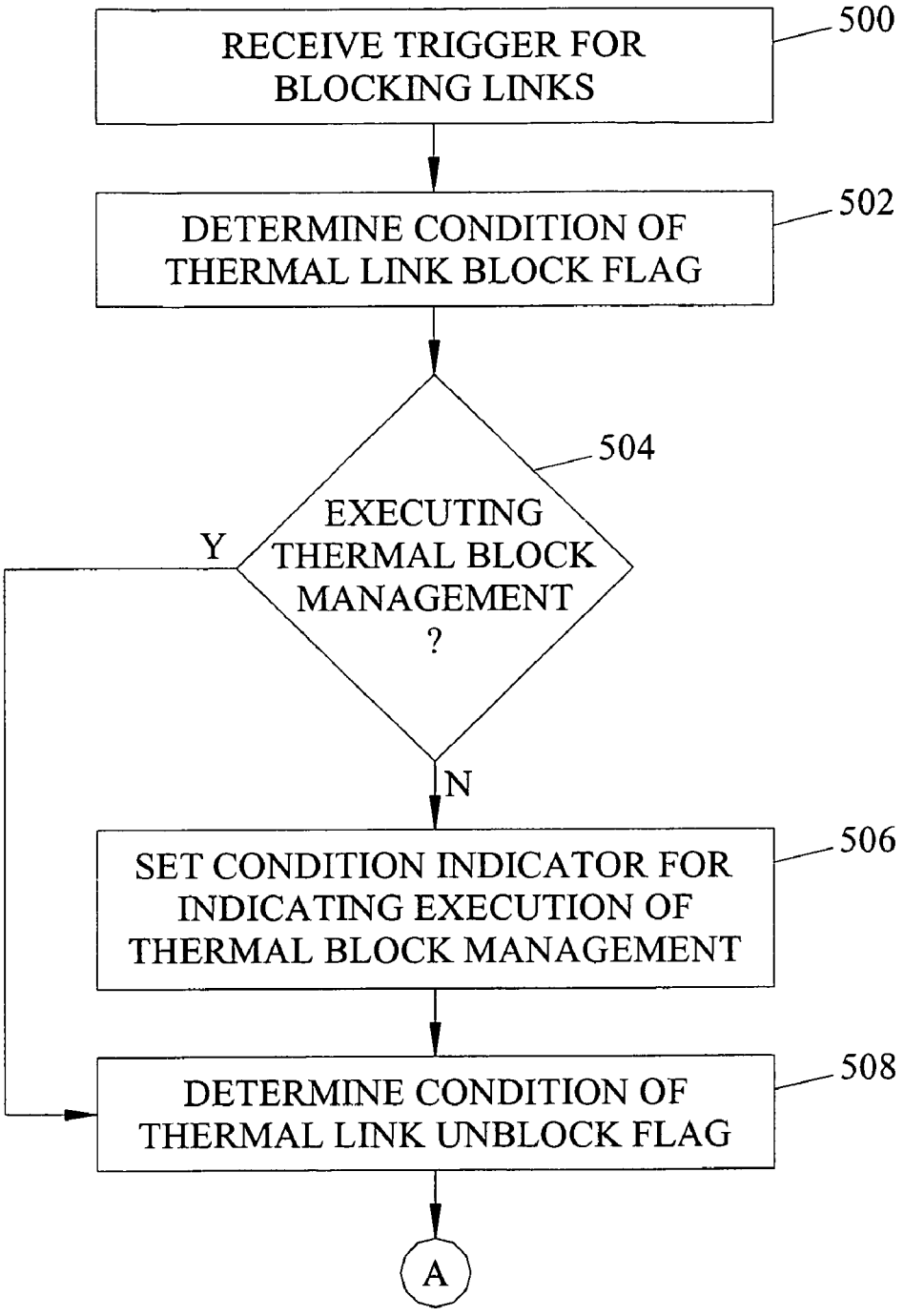

RECEIVE TRIGGER FOR BLOCKING LINKS
500
DETERMINE CONDITION OF THERMAL LINK BLOCK FLAG
502
EXECUTING THERMAL BLOCK MANAGEMENT ?
504
Y
N
SET CONDITION INDICATOR FOR INDICATING EXECUTION OF THERMAL BLOCK MANAGEMENT
506
DETERMINE CONDITION OF THERMAL LINK UNBLOCK FLAG
508
A

FIG. 5A

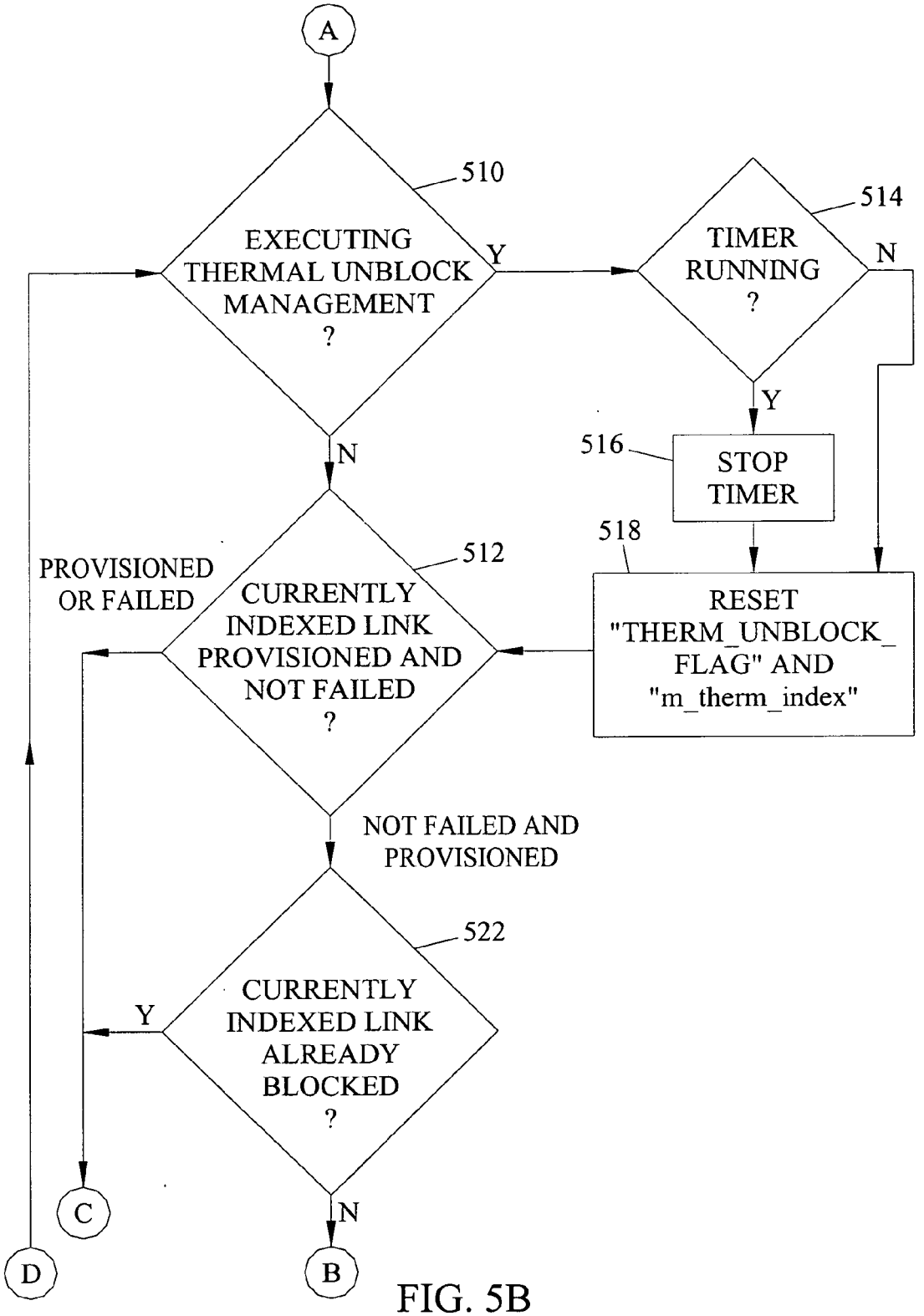

A
510
EXECUTING THERMAL UNBLOCK MANAGEMENT ?
Y
514
TIMER RUNNING ?
N
Y
516
STOP TIMER
518
RESET "THERM_UNBLOCK_ FLAG" AND "m_therm_index"
N
512
CURRENTLY INDEXED LINK PROVISIONED AND NOT FAILED ?
PROVISIONED OR FAILED
NOT FAILED AND PROVISIONED
522
CURRENTLY INDEXED LINK ALREADY BLOCKED ?
Y
N
C
D
B

FIG. 5B

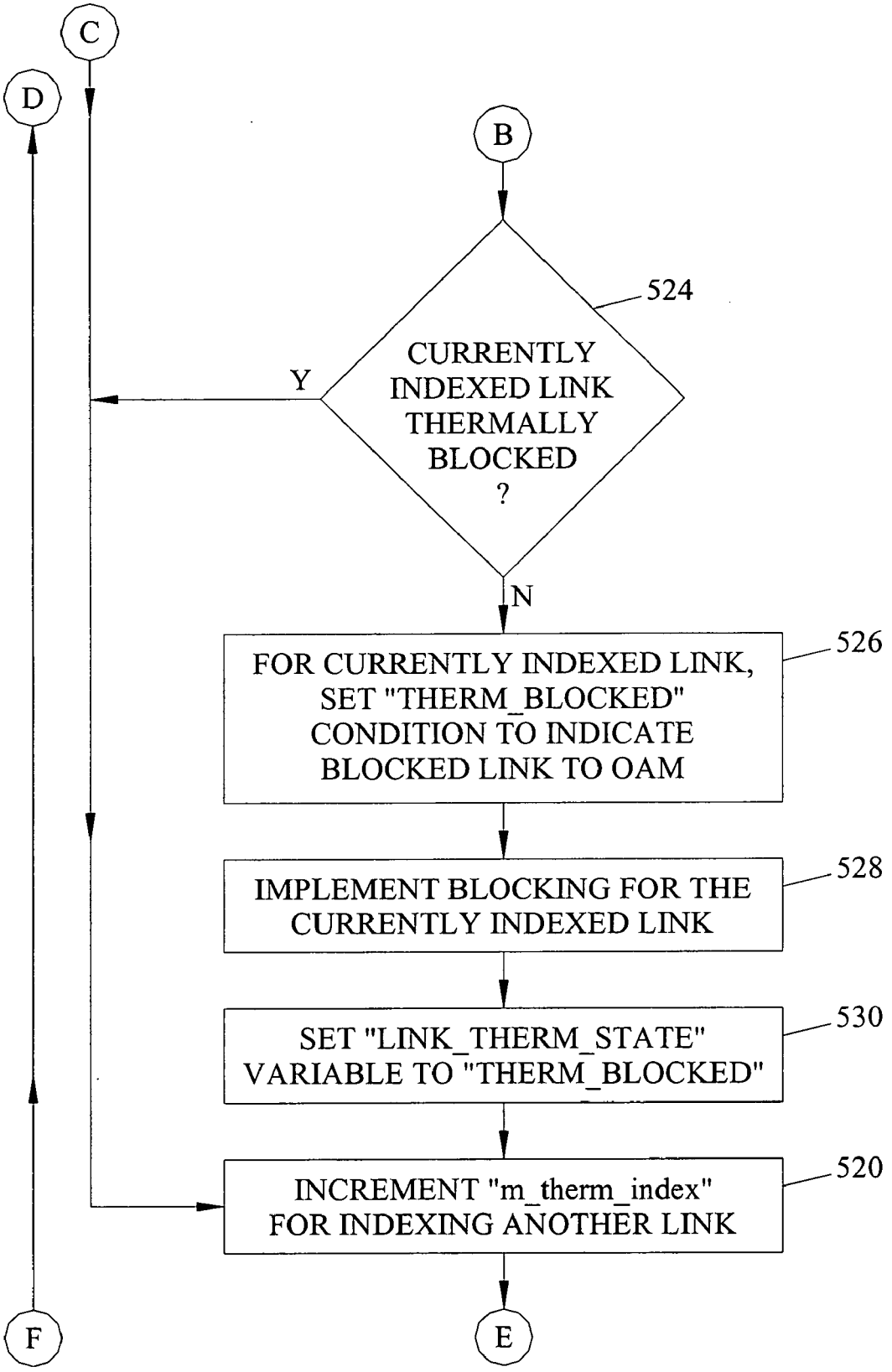

C
D
B
524
CURRENTLY INDEXED LINK THERMALLY BLOCKED ?
Y
N
FOR CURRENTLY INDEXED LINK, SET "THERM_BLOCKED" CONDITION TO INDICATE BLOCKED LINK TO OAM
526
IMPLEMENT BLOCKING FOR THE CURRENTLY INDEXED LINK
528
SET "LINK_THERM_STATE" VARIABLE TO "THERM_BLOCKED"
530
INCREMENT "m_therm_index" FOR INDEXING ANOTHER LINK
520
F
E

FIG. 5C

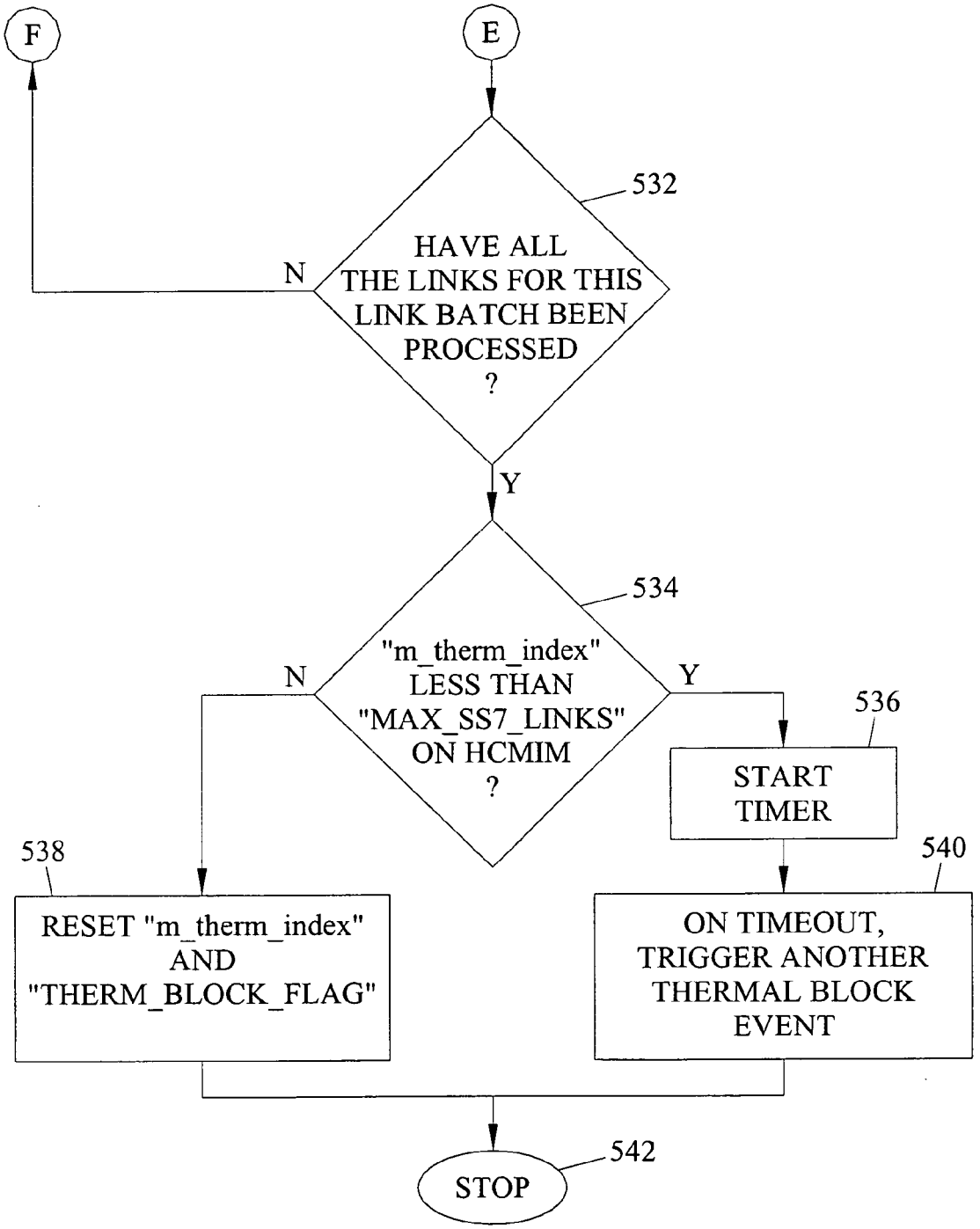

F
E
532
HAVE ALL THE LINKS FOR THIS LINK BATCH BEEN PROCESSED ?
N
Y
534
"m_therm_index" LESS THAN "MAX_SS7_LINKS" ON HCMIM ?
N
Y
536
START TIMER
538
RESET "m_therm_index" AND "THERM_BLOCK_FLAG"
540
ON TIMEOUT, TRIGGER ANOTHER THERMAL BLOCK EVENT
542
STOP

FIG. 5D

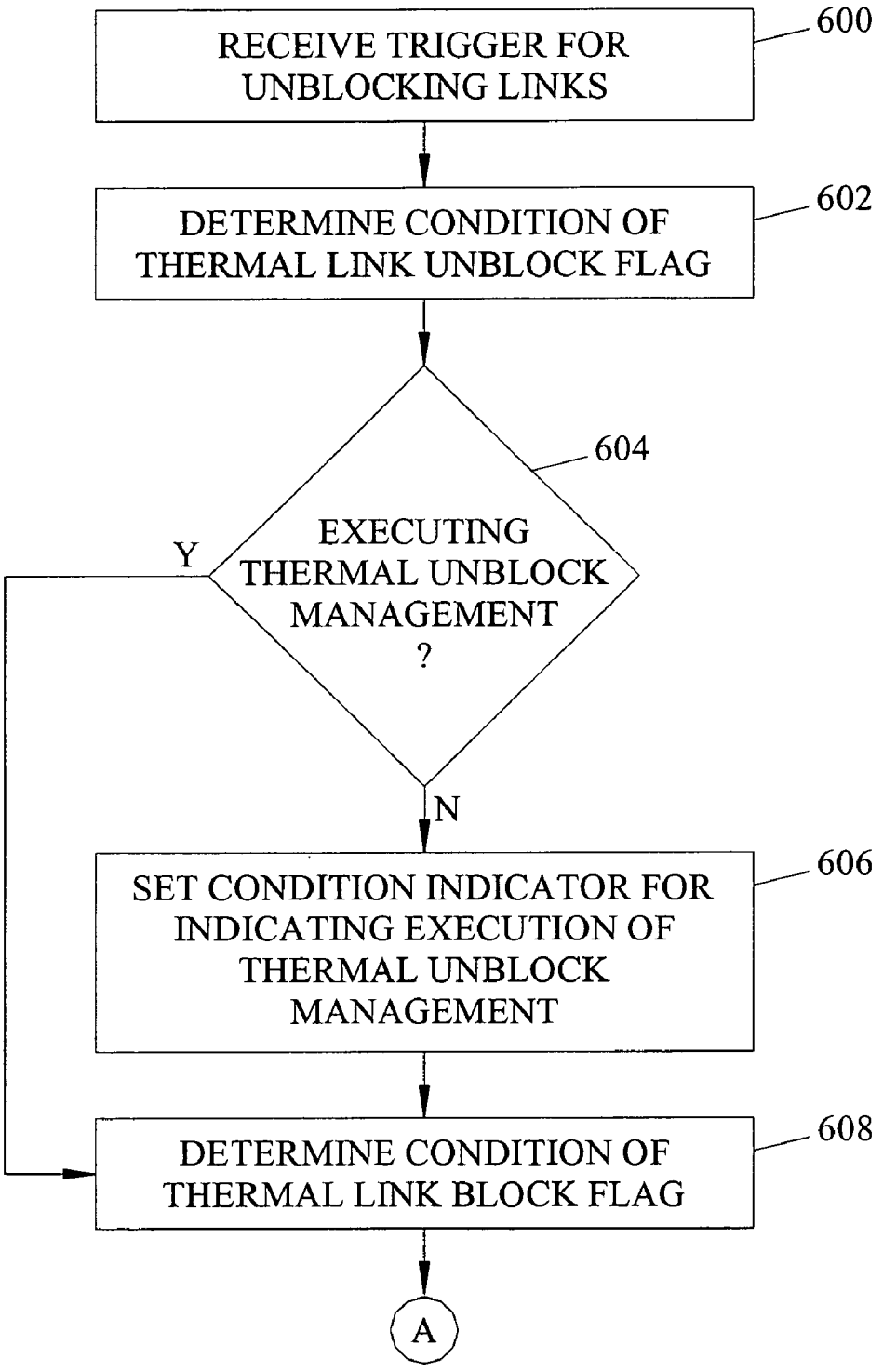

RECEIVE TRIGGER FOR UNBLOCKING LINKS
600
DETERMINE CONDITION OF THERMAL LINK UNBLOCK FLAG
602
EXECUTING THERMAL UNBLOCK MANAGEMENT ?
604
Y
N
SET CONDITION INDICATOR FOR INDICATING EXECUTION OF THERMAL UNBLOCK MANAGEMENT
606
DETERMINE CONDITION OF THERMAL LINK BLOCK FLAG
608
A

FIG.6A

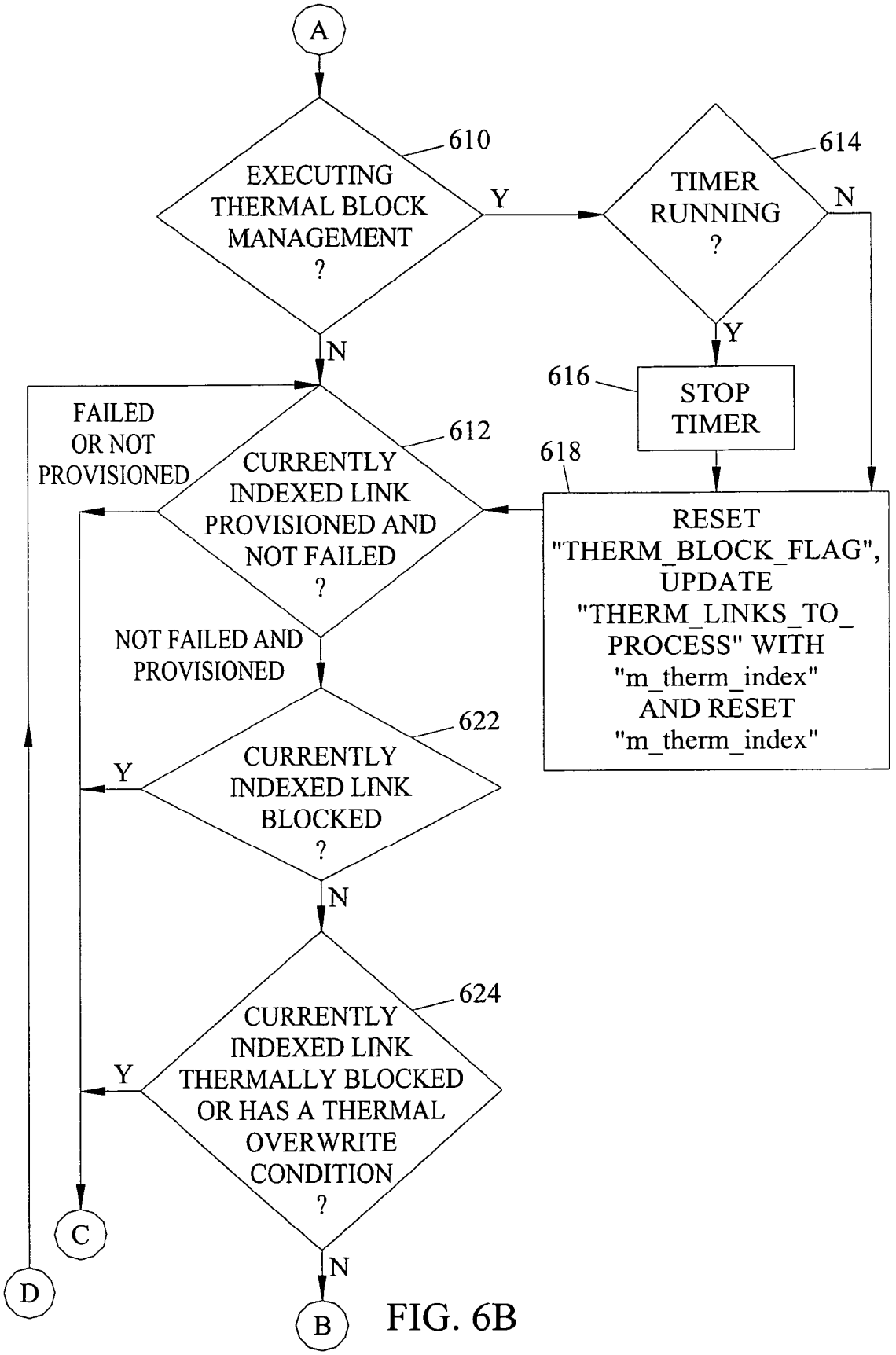

A
610
EXECUTING THERMAL BLOCK MANAGEMENT ?
Y
614
TIMER RUNNING ?
N
Y
N
616
STOP TIMER
618
RESET "THERM_BLOCK_FLAG", UPDATE "THERM_LINKS_TO_PROCESS" WITH "m_therm_index" AND RESET "m_therm_index"
612
CURRENTLY INDEXED LINK PROVISIONED AND NOT FAILED ?
FAILED OR NOT PROVISIONED
NOT FAILED AND PROVISIONED
622
CURRENTLY INDEXED LINK BLOCKED ?
Y
N
624
CURRENTLY INDEXED LINK THERMALLY BLOCKED OR HAS A THERMAL OVERWRITE CONDITION ?
Y
N
C
D
B

FIG. 6B

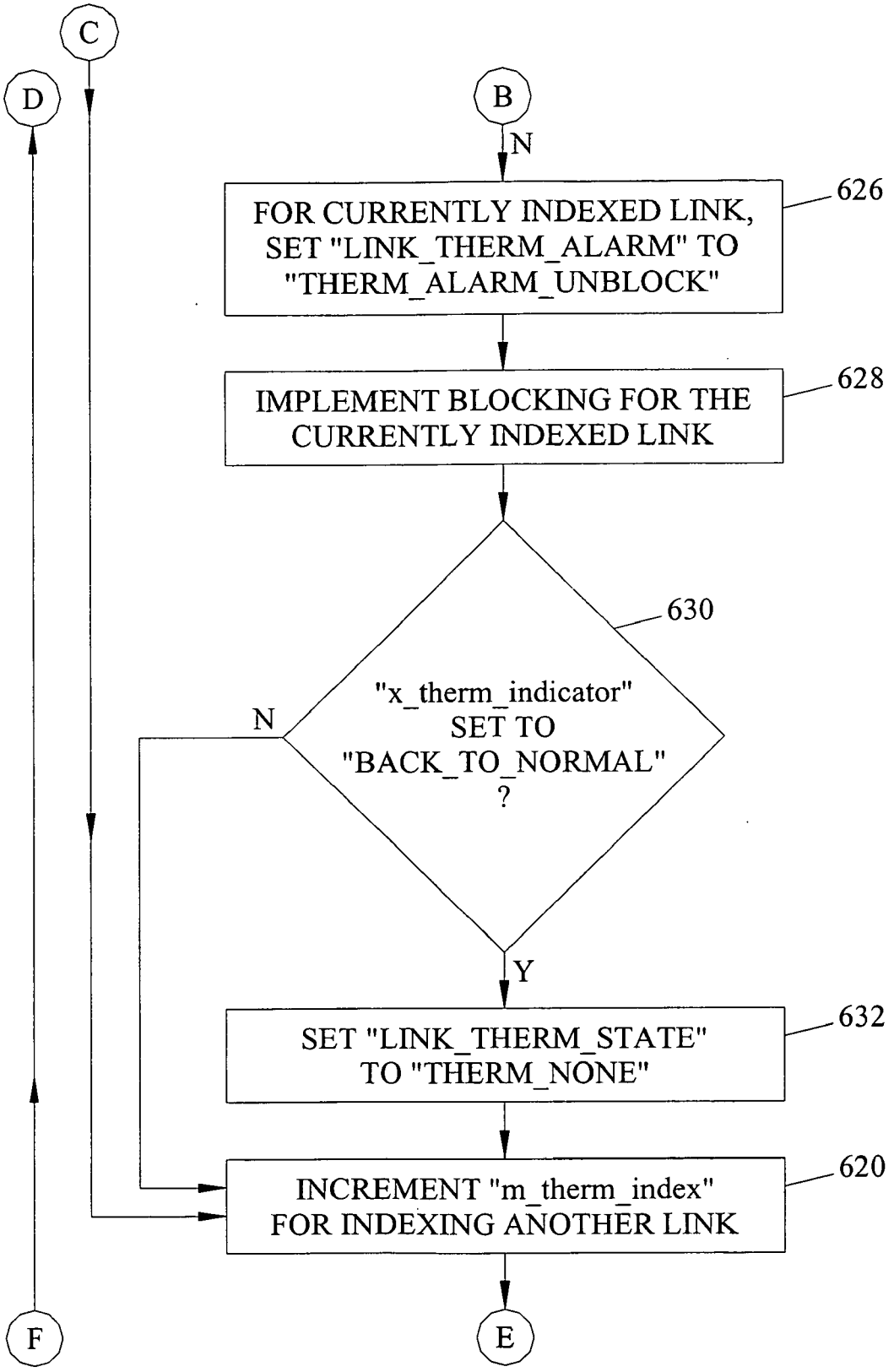

C
D
B
N
FOR CURRENTLY INDEXED LINK, SET "LINK_THERM_ALARM" TO "THERM_ALARM_UNBLOCK"
626
IMPLEMENT BLOCKING FOR THE CURRENTLY INDEXED LINK
628
"x_therm_indicator" SET TO "BACK_TO_NORMAL" ?
630
N
Y
SET "LINK_THERM_STATE" TO "THERM_NONE"
632
INCREMENT "m_therm_index" FOR INDEXING ANOTHER LINK
620
F
E

FIG. 6C

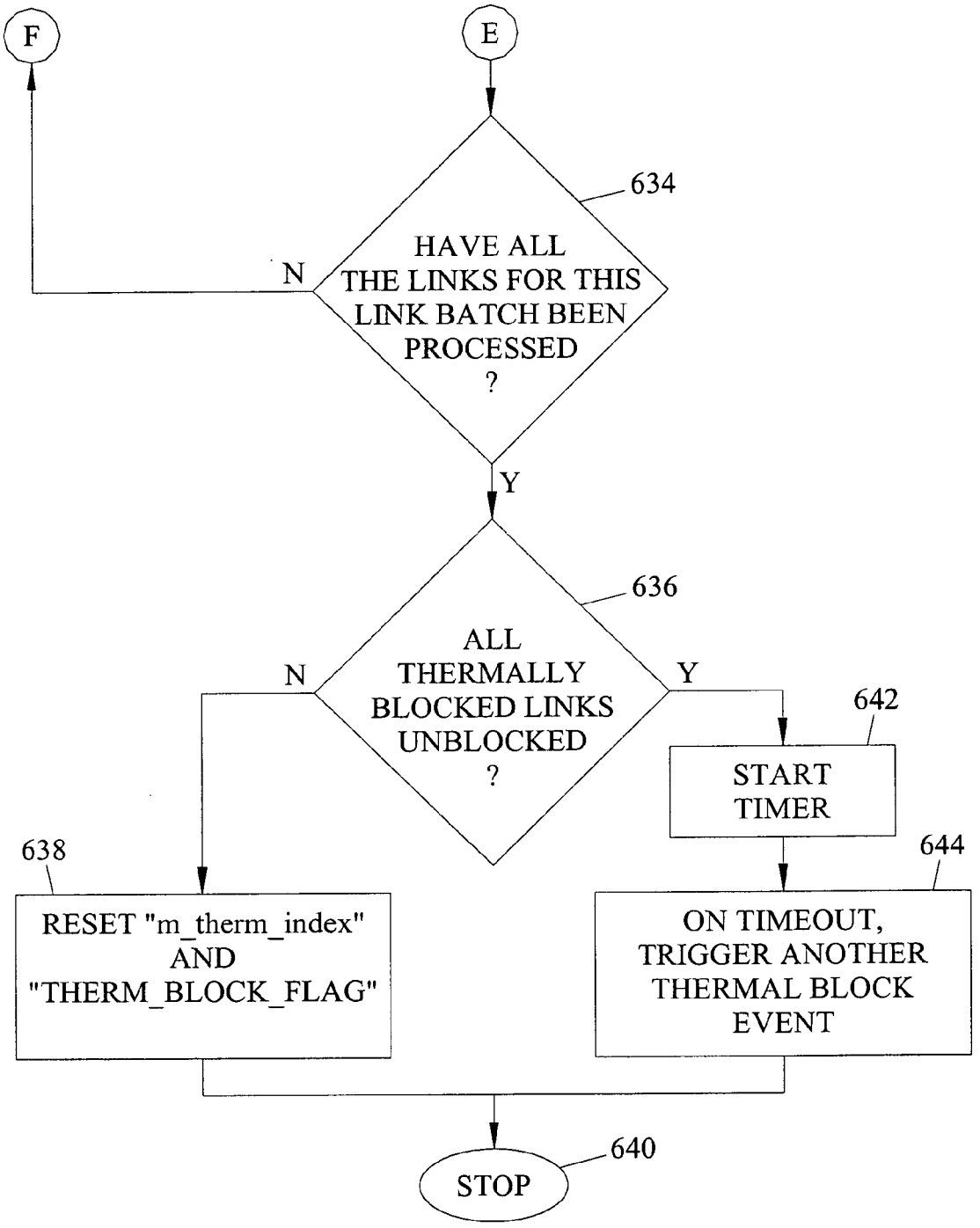

F
E
634
HAVE ALL THE LINKS FOR THIS LINK BATCH BEEN PROCESSED ?
N
Y
636
ALL THERMALLY BLOCKED LINKS UNBLOCKED ?
N
Y
642
START TIMER
638
RESET "m_therm_index" AND "THERM_BLOCK_FLAG"
644
ON TIMEOUT, TRIGGER ANOTHER THERMAL BLOCK EVENT
640
STOP

FIG. 6D

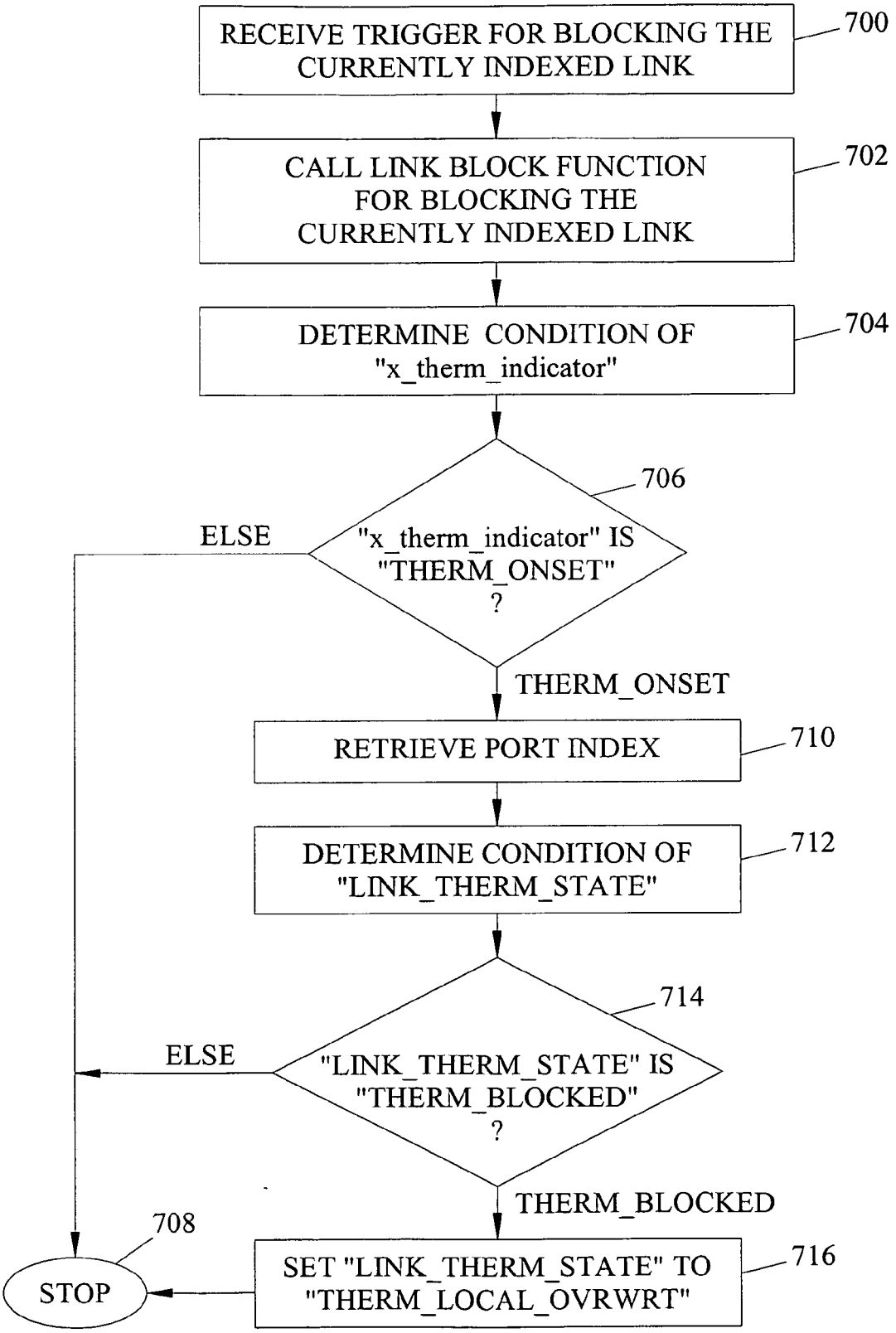

RECEIVE TRIGGER FOR BLOCKING THE CURRENTLY INDEXED LINK
700
CALL LINK BLOCK FUNCTION FOR BLOCKING THE CURRENTLY INDEXED LINK
702
DETERMINE CONDITION OF "x_therm_indicator"
704
706
"x_therm_indicator" IS "THERM_ONSET" ?
ELSE
THERM_ONSET
RETRIEVE PORT INDEX
710
DETERMINE CONDITION OF "LINK_THERM_STATE"
712
714
"LINK_THERM_STATE" IS "THERM_BLOCKED" ?
ELSE
THERM_BLOCKED
708
STOP
SET "LINK_THERM_STATE" TO "THERM_LOCAL_OVRWRT"
716

FIG. 7

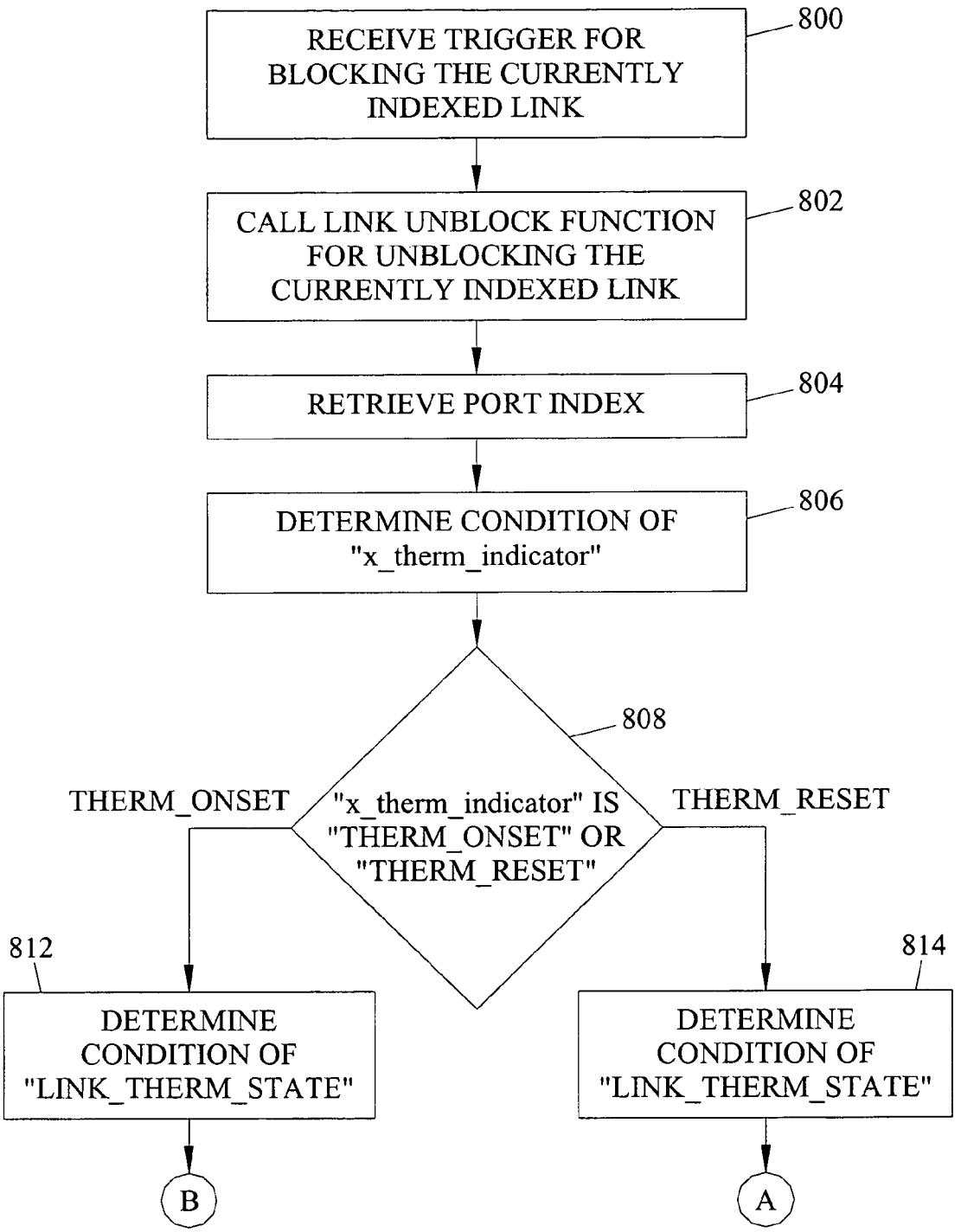

RECEIVE TRIGGER FOR BLOCKING THE CURRENTLY INDEXED LINK
800
CALL LINK UNBLOCK FUNCTION FOR UNBLOCKING THE CURRENTLY INDEXED LINK
802
RETRIEVE PORT INDEX
804
DETERMINE CONDITION OF "x_therm_indicator"
806
808
"x_therm_indicator" IS "THERM_ONSET" OR "THERM_RESET"
THERM_ONSET
THERM_RESET
812
DETERMINE CONDITION OF "LINK_THERM_STATE"
814
DETERMINE CONDITION OF "LINK_THERM_STATE"
B
A

FIG.8A

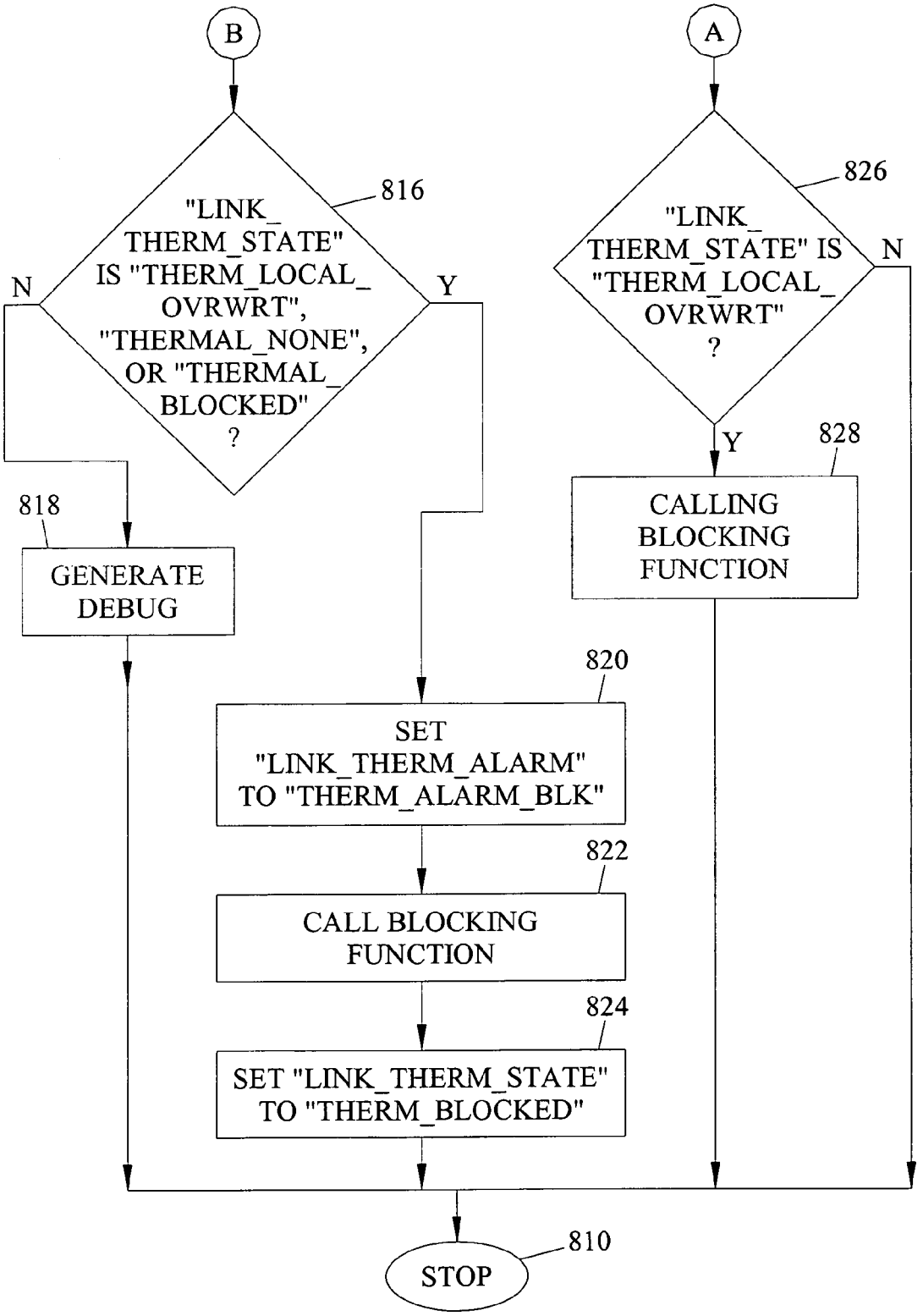

B
A
"LINK_ THERM_STATE" IS "THERM_LOCAL_ OVRWRT", "THERMAL_NONE", OR "THERMAL_ BLOCKED" ?
816
N
Y
"LINK_ THERM_STATE" IS "THERM_LOCAL_ OVRWRT" ?
826
N
Y
828
CALLING BLOCKING FUNCTION
818
GENERATE DEBUG
820
SET "LINK_THERM_ALARM" TO "THERM_ALARM_BLK"
822
CALL BLOCKING FUNCTION
824
SET "LINK_THERM_STATE" TO "THERM_BLOCKED"
STOP
810

FIG.8B

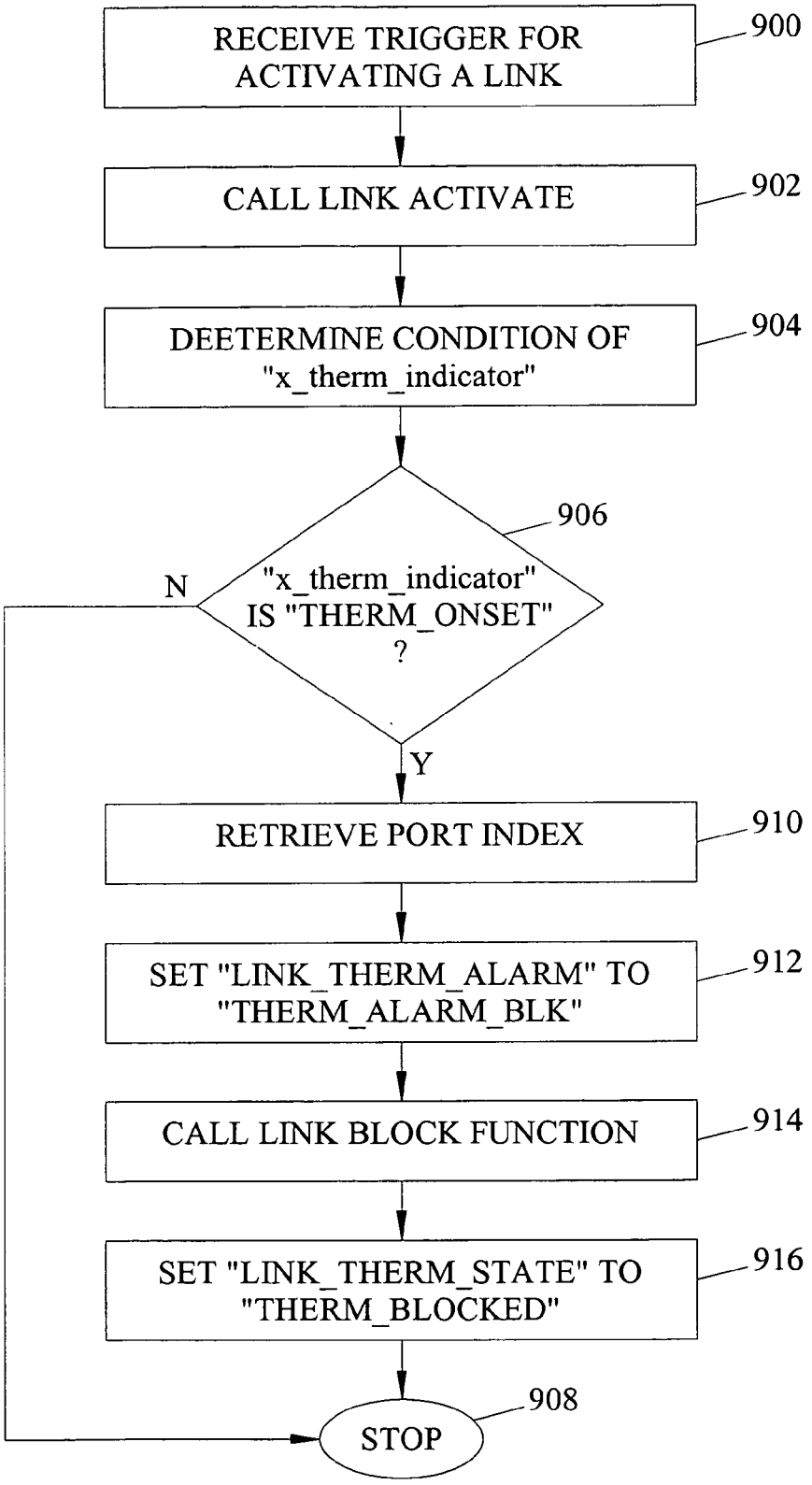

RECEIVE TRIGGER FOR ACTIVATING A LINK
900
CALL LINK ACTIVATE
902
DEETERMINE CONDITION OF "x_therm_indicator"
904
"x_therm_indicator" IS "THERM_ONSET" ?
906
N
Y
RETRIEVE PORT INDEX
910
SET "LINK_THERM_ALARM" TO "THERM_ALARM_BLK"
912
CALL LINK BLOCK FUNCTION
914
SET "LINK_THERM_STATE" TO "THERM_BLOCKED"
916
STOP
908

FIG. 9

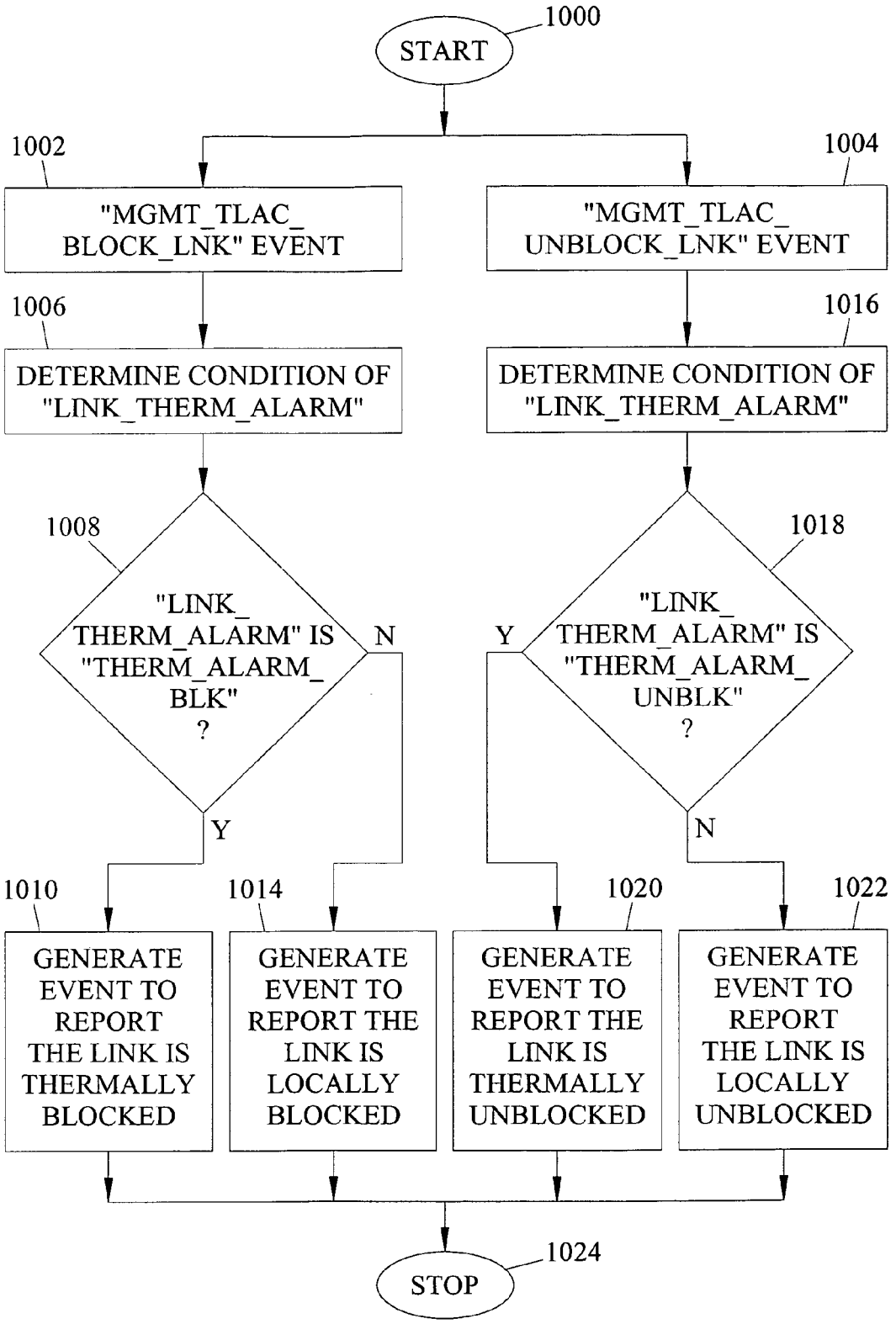

1000
START
1002
"MGMT_TLAC_ BLOCK_LNK" EVENT
1004
"MGMT_TLAC_ UNBLOCK_LNK" EVENT
1006
DETERMINE CONDITION OF "LINK_THERM_ALARM"
1016
DETERMINE CONDITION OF "LINK_THERM_ALARM"
1008
"LINK_ THERM_ALARM" IS "THERM_ALARM_ BLK" ?
N
Y
1018
"LINK_ THERM_ALARM" IS "THERM_ALARM_ UNBLK" ?
Y
N
1010
GENERATE EVENT TO REPORT THE LINK IS THERMALLY BLOCKED
1014
GENERATE EVENT TO REPORT THE LINK IS LOCALLY BLOCKED
1020
GENERATE EVENT TO REPORT THE LINK IS THERMALLY UNBLOCKED
1022
GENERATE EVENT TO REPORT THE LINK IS LOCALLY UNBLOCKED
1024
STOP

FIG. 10

METHODS, SYSTEMS AND COMPUTER PROGRAM PRODUCTS FOR THERMAL MANAGEMENT OF A PROCESSOR ASSOCIATED WITH A NETWORK INTERFACE

TECHNICAL FIELD

[0001] The subject matter described herein relates to network interfaces. More particularly, the subject matter described herein relates to methods, systems, and computer program products for thermal management of a processor associated with a network interface.

BACKGROUND ART

[0002] In telecommunications networks, nodes terminate links that carry message traffic, such as signaling and voice data. For example, in a signaling system 7 (SS7) telecommunications network, signal transfer point (STP) nodes terminate SS7 signaling links that carry signaling data. An STP node can include a plurality of network interface modules for terminating a plurality of signaling links. Each network interface module may include one or more processors for managing the transmission and receipt of message traffic over its links. For example, a network interface module may include an application processor operable to perform suitable communications functions, such as SS7 protocol functions, for the communication of signaling data. Alternatively, an application processor of a network interface module can implement Internet protocol (IP) functions for communicating with IP links.

[0003] High speed links can place a heavy burden on processors sending and receiving the message traffic over these links. For example, a link interface module may terminate many high speed links. The application processor on the link interface module must send and receive data over the high speed links at line rates or near line rates to avoid excessive buffering of signaling messages. Such processing can cause the temperature of the application processor to increase.

[0004] Some commercially available microprocessors are equipped with temperature managing mechanisms. These processors typically include a thermal sensor and a thermal control circuit (TCC) provided on the die to measure the temperature of the die. When the measured value exceeds a threshold value, the TCC reduces power consumption by periodically and repeatedly pausing processes internal to the processor core at a given cycle, and lowers the temperature by reducing the amount of heat generated. A processor may also completely shut down when its temperature level is above a second threshold value to a void damage to the chip. In addition, processors may provide a thermal warning to an operator when the processor temperature reaches or exceeds a threshold value. In a telecommunications environment, the stopping or shutting down of processors for managing message traffic is undesirable because message traffic on its associated link may be lost. Further, message traffic may be slowed or stopped.

[0005] In order to reduce the likelihood of the processor overheating in a signal transfer point, mechanical devices, such as fans, have been provided to cool the processors. Unlike personal computers where fans can be located on or adjacent to a processor, in high speed telecommunications equipment, such location is not possible due to close spacing of the link interface module. Accordingly, tray fans may be located above or below groups of link interface modules to control the processor temperature of the link interface module. Even though such fan banks or trays provide a mechanical mechanism for controlling processor temperature, overheating can still occur in light of the high processing mode on some processors. If overheating occurs and results in processor shutdown, signaling traffic will be lost and calls and call set up attempts may be interrupted.

[0006] Accordingly, there exists a need for methods, systems, and computer program products for providing thermal management of signaling link over network interface modules in a manner that prevents or reduces message traffic loss due to processor temperature.

SUMMARY

[0007] According to one aspect, the subject matter described herein includes methods, systems, and computer program products for thermal management of a processor associated with a network interface. A method for such thermal management of a network interface may include sending and receiving message traffic using a first processor associated with a first network interface. The message traffic may include, for example, signaling data, voice data, video data, non-voice audio data, and/or user data that is communicated on an SS7 signaling link, IP signaling link, or a voice over IP channel. Further, the method may include determining a temperature associated with the first processor. The temperature may be determined by a thermal sensor. The method may also include switching the message traffic from the first processor to a second processor in response to the temperature associated with the first processor having a predetermined relationship with respect to a threshold value. The threshold value can be less than a thermal shutdown level of the processor. As a result, message traffic is not lost due to a thermal shutdown of the processor because message traffic is switched to the second network interface prior to the processor temperature rising above the shutdown temperature.

[0008] The methods and systems described herein for thermal management of a processor associated with the network interface may be implemented as a computer program product comprising computer executable instructions embodied in a computer readable medium. Exemplary computer readable media suitable for implementing the subject matter described herein includes microprocessors that execute memory stored on chip memory devices, disc memory devices, or other suitable memory devices, applications specific integrated circuits, reconfigurable logic devices, and downloadable electrical systems.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Preferred embodiments of the subject matter described herein will now be explained with reference to the accompanying drawings of which:

[0010] **FIG. 1** is a block diagram illustrating an exemplary STP architecture including interface module thermal management applications according to an embodiment of the subject matter described herein;

[0011] **FIG. 2** is a block diagram of an exemplary internal architecture of an interface module including a thermal

management application according to an embodiment of the subject matter described herein;

[0012] **FIG. 3** is a flow chart of a process implemented by a callback function for managing a thermal indicator parameter according to an embodiment of the subject matter described herein;

[0013] **FIG. 4** is a flow chart of a process implemented by a thermal management application for controlling an SS7 management module to switch message traffic according to an embodiment of the subject matter described herein;

[0014] **FIGS. 5A-5D** are a flow chart of a process implemented by an SS7 management module for blocking links of an interface module according to an embodiment of the subject matter described herein;

[0015] **FIGS. 6A-6D** are a flow chart of a process implemented by an SS7 management module for unblocking links of an interface module according to an embodiment of the subject matter described herein;

[0016] **FIG. 7** is a flow chart of a process of a blocking function according to an embodiment of the subject matter described herein;

[0017] **FIGS. 8A-8B** are a flow chart of a process of an unblocking function according to an embodiment of the subject matter described herein;

[0018] **FIG. 9** is a flow chart of a process for activating a link of an interface module according to one embodiment of the subject matter described herein; and

[0019] **FIG. 10** is a flow chart of a process for indicating the occurrence of link blocking or unblocking to an operations, administration, and maintenance module according to an embodiment of the subject matter described herein.

DETAILED DESCRIPTION

[0020] Methods, systems, and computer program products for thermal management of a processor associated with a network interface according to embodiments of the subject matter described herein may be implemented in any suitable network communications device, such as a signal transfer point (STP), an IP router, a media gateway, or any other device that sends and receives packetized telecommunications signaling and/or voice data. In one exemplary implementation, the network communications device includes first network interface for sending and receiving message traffic over a network and first processor associated with the first network interface module for controlling the sending and receiving of the message traffic over the first network interface. The message traffic may include any suitable type of traffic such as signaling data, voice data, video data, non-voice audio data, and/or user data communicated on a telecommunications link such as an SS7 signaling link or an IP link. The network communications device may also include a second processor configured to control the sending and receiving of message traffic over a network. Further, the network communications device can include a temperature sensor for sensing a temperature associated with the first processor. Further, the network communications device may include a thermal management application associated with the temperature sensor and the first processor for determining whether the temperature has a predetermined relationship with respect to a threshold value. In response to determining that the temperature has a predetermined relationship with respect to a threshold value, the thermal management application switches message traffic from the first processor to the second processor.

[0021] As stated above, the thermal shutdown of a processor handling message traffic can result in a loss of messages or a reduction in the transmission rate of the traffic. The subject matter described herein can prevent or reduce the effect of the thermal shutdown on message traffic. In one exemplary implementation, a network interface device according to the subject matter described herein switches message traffic away from a first processor when the temperature level of the first processor is above a temperature threshold value. The network traffic can be switched to a second processor such that communication of message traffic is not disrupted. When the temperature of the first processor falls below the temperature threshold value, message traffic can be switched back to the first processor from the second processor. The temperature threshold value can be set less than the thermal shutdown level of the first processor such that message traffic can be efficiently switched prior to shutdown of the first processor.

[0022] **FIG. 1** illustrates an exemplary STP architecture including one or more thermal management applications according to an embodiment of subject matters described herein. Referring to **FIG. 1**, STP **100** includes a plurality of network interface devices, referred to as high capacity multiport link interface modules (HCMIMs) **102**, **104**, and **106**, for interfacing with communications links, such as SS7 or IP links, that carry message traffic. In the illustrated embodiment, each HCMIM **102**, **104**, and **106** includes a plurality of ports, each capable of bidirectional SS7 or IP communications.

[0023] STP **100** may also include one or more internal processing modules, such as a database service module (DSM) **108** and an operations administration and maintenance (OAM) module **110** that do not interface directly with external communications links. For example, DSM **108** may provide database-related services, such as global title and number portability translations. OAM module **110** may perform database provisioning and manage the overall operation of STP **100**. Each of DSM **108** and OAM module **110** may be a printed circuit board with one or more processors mounted thereon. In one exemplary implementation, DSM **108** and OAM module **110** may each include an application processor for executing application programs and a communications processor for communicating with each other and HCMIMs **102**, **104**, and **106**. Modules **102**, **104**, **106**, **108**, and **110** may be connected by one or more buses **112** for providing interprocessor communications. In the illustrated example, buses **112** comprise a pair of counter-rotating dual rings. In an alternate implementation, buses **312** may be replaced by an Ethernet LAN.

[0024] HCMIMs **102**, **104**, and **106** may each include a communications processor **114**, an application processor **116**, a network interface **117**, and an SS7 management module **118**. Each communications processor **114** is operable to provide communications among the HCMIMs and with DSM **108** and OAM module **110**. Each application processor **116** and network interface **117** is operable to send and receive message traffic on corresponding links. For example, each application processor **116** is operable to

execute SS7 functions stored in its corresponding SS7 management module **118**. The SS7 functions include instructions for implementing SS7 processes for sending and receiving signaling messages over SS7 signaling links.

[**0025**] As stated above, methods, systems, and computer program products according to the subject matter described herein can switch message traffic from an application processor of a first network interface module to an application processor of a second network interface module when the temperature level of the application processor of the first network interface module is greater than or equal to a threshold value. For example, the message traffic associated with application processor **116** of HCMIM **102** can be switched to application processor **116** or HCMIM **104** when the temperature of application processor **116** of HCMIM **102** is greater than or equal to the threshold value. According to one embodiment, HCMIMs **102**, **104**, and **106** may each include a temperature sensor **120** for measuring the temperature of application processor **116**. Each of HCMIMs **102**, **104**, and **106** can also include a thermal management application **122** for determining whether the measured temperature is greater than or equal to the threshold value. Temperature sensor **120** can be a component of application processor **116**, which includes a register for storing the measured temperature. Thermal management application **122** can monitor the register and determine whether the temperature is greater than or equal to a stored threshold value. In response to determining that the temperature is greater than or equal to the threshold value, thermal management application **122** can control the switching of message traffic to HCMIM **104** or HCMIM **106**. The threshold value may be set to a temperature less than the shutdown temperature of application processor **116**. In this manner, traffic can be switched to another HCMIM before application processor **116** shuts down due to temperature.

[**0026**] The subject matter described herein is not limited to switching message traffic from an application processor on one interface module to application processor on another interface module when the temperature of the application processor on the first interface module exceeds the threshold value. In an alternative implementation, multiple application processors may be located on the same network interface module. In such an implementation, the thermal management application **122** may switch message traffic from a first application processor on a first interface module to a second application processor on the first interface module. Similarly, the subject matter described herein is not limited to switching message traffic to a new network interface when the temperature of an application processor exceeds a threshold. For example, multiple application processors may be associated with the same network interface. In such an implementation, thermal management application may switch message traffic from an overheated application processor to another application processor associated with the same network interface.

[**0027**] After message traffic is switched from an HCMIM, the temperature of the application processor of the HCMIM may reduce because of the reduction in load on the processor. When the processor reaches a temperature below a threshold value, message traffic may be switched back to the HCMIM after a predetermined time period. For example, message traffic can be switched from HCMIM **104** to HCMIM **102** when the temperature of HCMIM **102** falls below the threshold value for a predetermined time period. In order to determine whether to switch back from HCMIM **102**, thermal management application **122** of HCMIM **102** can determine whether the temperature measured by temperature sensor **120** is less than the threshold value. In response to determining that the temperature of application processor **116** of HCMIM **102** is less than the threshold value for the predetermined time period, thermal management application **122** of HCMIM **102** can control the switching of message traffic back to HCMIM **102**. In this manner, traffic can be switched back to HCMIM **102** when application processor **122** of HCMIM **102** is consistently below its shutdown temperature. The predetermined time period can be a suitable time period (e.g., one second) such that application processor **122** is at a stable temperature below the processor shutdown temperature.

[**0028**] **FIG. 2** is a block diagram illustrating exemplary internal architecture of HCMIM **102** according to an embodiment of the subject matter described herein. In **FIG. 2**, HCMIM **102** can include a board service package (BSP) **200** for receiving temperature measurements from thermal sensor **120**. For example, BSP **200** can poll a register of application processor **116** storing a temperature measurement of application processor **116**. As stated above, thermal sensor **120** is operable to measure the temperature of application processor **116**. BSP **200** can store the temperature measurement in a temperature measurement buffer **202**.

[**0029**] An interrupt generator **204** of BSP **200** can continuously monitor the temperature measurement within buffer **202**. If the temperature measurement rises above than a threshold value, interrupt generator **204** can generate an interrupt to a callback function **206** within thermal management application **122**. The threshold value can be set to a temperature below the shutdown temperature of application processor **116**. Thus, an interrupt can be generated at a threshold value below the shutdown temperature. Interrupt generator **204** can also generate an interrupt when the temperature measurement falls below a second threshold value.

[**0030**] According to one embodiment, interrupt generator **204** can pass a "THERM_STATE" parameter to callback function **206** of thermal management application **122** for indicating an ONSET condition or an ABATEMENT condition. The ONSET condition indicates that the temperature of application processor **116** is rising above the threshold value. The ABATEMENT condition indicates that the temperature of application processor **116** is falling below the threshold value. The "THERM_STATE" parameter may be set to 1 for indicating the ONSET condition. In addition, the "THERM_STATE" parameter may be set to 0 for indicating the ABATEMENT condition.

[**0031**] Callback function **206** may manage a thermal indicator parameter, designated "x_therm_indicator" parameter, for indicating an ONSET condition or an ABATEMENT condition. Callback function **206** may continuously run and check the "THERM_STATE" parameter generated by interrupt generator **204** for updating the thermal indicator parameter. **FIG. 3** is a flow chart illustrating a process implemented by callback function **206** for managing the "x_therm_indicator" parameter according to an embodiment of the subject matter described herein. Referring to **FIG. 3**, the process starts at step **300** when callback function **206** is

called by interrupt generator **204**. At step **300**, callback function **206** determines the condition of "THERM_STATE" parameter. Next, at step **302**, callback function **206** determines whether the "THERM_STATE" parameter indicates an ONSET condition. If the "THERM_STATE" parameter indicates the ONSET condition, the process proceeds to step **304**. At step **304**, the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_ONSET" for indicating that the threshold value of application processor **116** has been exceeded. Next, the process stops at step **306**.

[**0032**] Referring again to step **302**, if the "THERM_STATE" parameter is not set to the ONSET condition, the process proceeds to step **308**. At step **308**, callback function **206** determines the condition of the "x_therm_indicator" parameter. Next, at step **310**, it is determined whether the "x_therm_indicator" parameter is set to the "THERM_THRESHOLD_NORMAL" condition or the "THERM_THRESHOLD_RESET" condition. The "THERM_THRESHOLD_NORMAL" condition indicates that application processor **116** is currently at a normal operating temperature below the threshold value. The "THERM_THRESHOLD_RESET" condition indicates that an operator has reset the temperature of application processor **116** to a nominal operating condition. If the "x_therm_indicator" parameter is set to the "THERM_THRESHOLD_NORMAL" condition, the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_ABATE" (step **312**) and the process stops (step **306**). On the other hand, if the "x_therm_indicator" parameter is set to the "THERM_THRESHOLD_RESET" condition, the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_ABATE" (step **314**) and the process stop (step **306**). Otherwise, if the "x_therm_indicator" parameter is neither "THERM_THRESHOLD_RESET" nor "THERM_THRESHOLD_NORMAL", the process stops at step **306**.

[**0033**] On updating the "x_therm_indicator" parameter, a message may be sent to an SS7 management module **118** for switching message traffic on the links of application processor **116**. For example, thermal management application **122** can control SS7 management module **118** to block traffic on the links of HCMIM **102** and start switching traffic from application processor **116** to another application processor when the "x_therm_indicator" parameter is set to the "THERM_THRESHOLD_ONSET" condition. Further, for example, thermal management application **122** can control module **118** to unblock the message traffic of application processor **116** and start switching traffic from another application processor to application processor **116** when the "x_therm_indicator" parameter is set to the "THERM_THRESHOLD_ABATE" condition. According to one embodiment, thermal management application **122** can execute a process checking the "x_therm_indicator" parameter at least once every heartbeat. For example, the "x_therm_indicator" parameter may be checked once every 5 milliseconds (ms).

[**0034**] **FIG. 4** is a flow chart illustrating a process implemented by thermal management application **122** for controlling SS7 management module **118** to switch message traffic according to an embodiment of the subject matter described herein. The process may run periodically for checking the condition of the "x_therm_indicator" parameter. Referring to **FIG. 4**, the process starts at step **400** where module **206** determines the condition of the "x_therm_indicator" parameter. Next, at step **402**, module **208** determines whether the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_ONSET", "THERM_THRESHOLD_ABATE", "THERM_THRESHOLD_NORMAL", "THERM_THRESHOLD_DISCARD", or "THERM_THRESHOLD_RESET".

[**0035**] As stated above, a "THERM_THRESHOLD_ONSET" condition indicates that the temperature of application processor **116** is above the threshold value. If the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_ONSET", the process proceeds to step **404** where a thermal link block event ("PMTC_THERM_BLOCK_LNK"**208** shown in **FIG. 2**) of application **122** is triggered. Thermal management application **122** may trigger a thermal link block event by transmitting a level 3 SS7 management signal (L**3**) signal to SS7 management module **118** for initiating thermal link block event **208**. Thermal link block event **208** initiates traffic switching from application processor **116** and link blocking on application processor **116**, as described in more detail herein. Next, at step **406**, the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_DISCARD" for indicating that application processor **116** is in a thermal exceed condition or that its message traffic is being switched. The process can then stop at step **408**.

[**0036**] As stated above, a "THERM_THRESHOLD_ABATE" condition indicates that the temperature of application processor **116** is less than the threshold value. If the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_ABATE", the process proceeds to step **410** where a thermal link unblock event ("PMTC_THERM_UNBLOCK_LNK"**212** shown in **FIG. 2**) within SS7 management module **118** is triggered. Thermal management application **122** may trigger a thermal link unblock event by transmitting an L**3** signal to SS7 management module **118** for indicating the ONSET condition and initiating the thermal link unblock event **210**. Thermal link unblock event **210** initiates traffic changeover to application processor **116** and link unblocking on application processor **116**, as described in more detail herein. Next, at step **412**, the "x_therm_indicator" parameter is set to "THERM_THRESHOLD_RESET" for indicating a thermal condition reset or that application processor **116** is in a normal condition. The process can then stop at step **408**.

[**0037**] Referring again to step **402**, if the "x_therm_indicator" variable is set to either "THERM_THRESHOLD_NORMAL", "THERM_THRESHOLD_DISCARD", or "THERM_THRESHOLD_RESET", the process can stop at step **408**. No action is necessary for these conditions.

[**0038**] Referring again to step **402**, if the condition of the "x_therm_indicator" parameter is neither "THERM_THRESHOLD_ONSET", "THERM_THRESHOLD_ABATE", "THERM_THRESHOLD_NORMAL", "THERM_THRESHOLD_DISCARD", nor "THERM_THRESHOLD_RESET", then the "x_therm_indicator" parameter is currently in an erroneous condition, and a debug error condition for the "x_therm_indicator" parameter is indicated by thermal management application **122** at step **414**. Next, the process stops at step **408**.

[**0039**] Referring to **FIG. 2**, thermal link block event ("PMTC_THERM_BLOCK_LNK") **208** of thermal man-

agement application **122** can be triggered when thermal management application **122** transmits an L3 signal to SS7 management module **118** for indicating the ONSET condition. According to one embodiment, HCMIM **102** can include 64 links for sending and receiving message traffic. For an HCMIM having 64 links, thermal link blocking may be completed in batches of 8 links at a time until all of the links are blocked. After every eighth link, a 500 ms timer is started. At the end of the 500 ms, the timer triggers for continuing blocking link batches where it left off in the link blocking process until all of the links are blocked. By providing 500 ms between blocking the link batches, the functionality as provided by processors can be made available for other uses in between the time period required for blocking a link batch.

[**0040**] **FIGS. 5A-5D** are a flow chart illustrating a process implemented by SS7 management module **118** for blocking links of HCMIM **102** according to an embodiment of the subject matter described herein. As described herein, the links of HCMIM **102** can be blocked in batches. For example, HCMIM **102** can have 64 links, divided into 8 batches of 8 links. Batches can be blocked in batches separated by a time interval separated by a timer.

[**0041**] Referring to **FIG. 5A**, the process for blocking the links of HCMIM **102** can be initiated when thermal management application **122** triggers thermal block event **208** by sending an L3 signal indicating an ONSET condition (step **404** of **FIG. 4**). Referring to **FIG. 5A**, the process begins at step **500** where PMTC management module **208** receives the L3 signal trigger for blocking the links of HCMIM **102**. Next, at step **502**, thermal management application **122** determines a condition of "THERM_BLOCK_FLAG" parameter, which indicates whether module **118** is executing thermal link block management. At step **504**, it is determined whether the "THERM_BLOCK_FLAG" parameter indicates that SS7 management module **118** is executing thermal link block management. If it is determined that module **118** is not executing thermal link block management at step **504**, the "THERM_BLOCK_FLAG" parameter is set to a condition for indicating execution of thermal block management (step **506**) and the process proceeds to step **508**. Otherwise, if it is determined that the "THERM_BLOCK_FLAG" parameter indicates execution of thermal link block management at step **504**, the process proceeds directly to step **508**.

[**0042**] At step **508** of **FIG. 5A**, SS7 management module **118** determines a condition of "therm_unblock_flag" parameter, which indicates whether thermal management application **122** is executing thermal link unblock management. As stated above, thermal link unblock management can be implemented by thermal link unblock event **210**. Next, at step **510** of **FIG. 5B**, it is determined whether the "THERM_UNBLOCK_FLAG" parameter indicates execution of thermal link unblock management. If it is determined that module **118** is not executing thermal link unblock management at step **510**, the process proceeds to step **512**. Otherwise, the process proceeds to step **514** where it is determined whether the 500 ms timer is running. If it is determined that the timer is running at step **514**, the timer is stopped at step **516** and the "therm_unblock_flag" parameter is reset at step **518** to indicate that unblocking is not being implemented. Further, at step **518**, an "m_therm_index" parameter indicating the start link index for thermal link management can be reset to 0 at step **518**. The "m_therm_index" parameter" can indicate the link of HCMIM **102** that is currently being processed. The link index "m_therm_index" parameter is reset such that blocking can begin at the first link of HCMIM **102**. Next, the process proceeds to step **512**.

[**0043**] Next, beginning at step **512** of **FIG. 5B**, the process begins blocking the links of HCMIM **102**. At each link of HCMIM **102**, application **122** determines whether the currently indexed link is failed and provisioned (step **512**). As stated above, the link index is indicated by the "m_therm_index" parameter. If the link is failed or not provisioned, the process proceeds to step **520**, described in further detail herein. Otherwise, if the link is provisioned and not failed, the process proceeds to step **522**.

[**0044**] At step **522**, it is determined whether the currently indexed link is already blocked. The link may be blocked locally by an operator or blocked for other reasons due to temperature as described further herein. If the currently indexed link is already blocked, the process may proceed to step **520**. Further processing of the link is not necessary because the link is already blocked. Otherwise, if the currently indexed link is not blocked, the process proceeds to step **524**.

[**0045**] Next, at step **524** of **FIG. 5C**, it is determined whether a "LINK_THERM_STATE" variable for the currently indexed link is set to a "THERM_BLOCKED" condition indicating that the link is unblocked by operator input. If the currently indexed link is thermally blocked, the process may proceed to step **520**. Otherwise, if the currently indexed link is not blocked, the process proceeds to step **526**.

[**0046**] Next, at step **526**, a "LINK_THERM_STATE" parameter for the currently indexed link is set to a "THERM_BLOCKED" condition for indicating to OAM **110** that the link is blocked. Upon notification of the condition, OAM **110** can implement blocking as described in further detail herein (step **528**). According to one embodiment, OAM **110** can call a blocking function **212** ("PMTC_BLOCK_LNK_FUNC") (shown in **FIG. 2**) for blocking the currently indexed link, as described in further detail below. In addition, OAM **110** can set up a buffer to store received message traffic during the operation of blocking function **212**. Next, a "LINK_THERM_STATE" parameter is set to "THERM_BLOCKED" condition (step **530**) for indicating that the link is currently blocked.

[**0047**] Next, the process proceeds to step **520** where the "m_therm_index" parameter is incremented by one for indexing another link. Next, at step **532** of **FIG. 5D**, it is determined whether all of the links for this link batch have been processed. If all of the links for this link batch have not been processed, the process proceeds back to step **512** for processing the currently indexed link, associated with the "m_therm_index" parameter incremented in step **520**. Otherwise, if all of the links for this link batch have been processed, the process proceeds to step **534**.

[**0048**] At step **534**, it is determined whether the current index for the "m_therm_index" parameter is less than the maximum number of links (indicated by a "MAX_SS7_LINKS" parameter) on HCMIM **102**. According to one embodiment, HCMIM **102** can have 64 links and therefore the maximum number of links is 64. If the current index is less than the maximum number of links, the process proceeds to step **536**. Otherwise, the process proceeds to step **538**.

[0049] Referring to step **536**, the timer is reset to 0 and started. The timer may be set to timeout at 500 ms. After the timeout of the timer at step **536**, another thermal link block event ("PMTC_THERM_BLOCK_LNK") can be triggered (step **540**). The process then stops at step **542**.

[0050] At step **538**, the "m_therm_index" and the "therm_block_flag" variables are reset. The process can then stop at step **542**.

[0051] Referring again to **FIG. 2**, thermal link unblock event ("PMTC_THERM_UNBLOCK_LNK") **210** can be triggered when thermal management application **122** transmits an L**3** signal to SS7 management module **118** for indicating the ABATEMENT condition. As stated above, HCMIM **102** according to one embodiment can include 64 links for sending and receiving message traffic. Similar to the link blocking process of **FIGS. 5A-5D**, thermal link unblocking may be completed in batches of 8 links at a time until all of the links of HCMIM **102** are unblocked.

[0052] **FIGS. 6A-6D** are a flow chart illustrating a process implemented by SS7 management module **118** for unblocking links of HCMIM **102** according to an embodiment of the subject matter described herein. As described herein, the links of HCMIM **102** can be unblocked in batches. For example, HCMIM **102** can have 64 links, divided into 8 batches of 8 links. Batches can be unblocked in batches separated by a time interval separated by a timer.

[0053] Referring to **FIG. 6A**, the process for unblocking the links of HCMIM **102** can be initiated when thermal management application **122** triggers a thermal block event by sending an L**3** signal indicating an ABATEMENT condition (step **410** of **FIG. 4**). Referring to **FIG. 6A**, the process begins at step **600** where SS7 management module **118** receives the L**3** signal trigger for unblocking the links of HCMIM **102**. Next, at step **602**, SS7 management module **118** determines a condition of "THERM_UNBLOCK_FLAG" parameter, which indicates whether module **118** is executing thermal link unblock management. At step **604**, it is determined whether the "THERM_UNBLOCK_FLAG" parameter indicates that SS7 management module **118** is executing thermal link unblock management. If it is determined that module **118** is not executing thermal link unblock management at step **604**, the "THERM_UNBLOCK_FLAG" parameter is set to a condition for indicating execution of thermal unblock management (step **606**) and the process proceeds to step **608**. Otherwise, if it is determined that SS7 management module **118** is executing thermal link block management at step **604**, the process proceeds directly to step **608**.

[0054] At step **608** of **FIG. 6A**, SS7 management module **118** determines a condition of the "THERM_UNBLOCK_FLAG" parameter, which indicates whether SS7 management module **118** is executing thermal link block management. As stated above, thermal link block management can be implemented by thermal link unblock event **208**. At step **610** of **FIG. 6B**, it is determined whether the "THERM_UNBLOCK_FLAG" parameter indicates that SS7 management module **118** is executing thermal link block management. If it is determined that module **118** is not executing thermal link block management at step **610**, the process proceeds to step **612**. Otherwise, the process proceeds to step **614** where it is determined whether the 500 ms timer is running. If it is determined that the timer is running at step **614**, the timer is stopped at step **616** and the "THERM_UNBLOCK_FLAG" parameter is reset at step **618**. Further, at step **618**, a "THERM_LINKS_TO_PROCESS" variable is updated with the "m_therm_index" parameter, and the "m_therm_index" parameter indicating the start link index for thermal link management can be reset to 0 at step **618**. Next, the process proceeds to step **612**.

[0055] Next, beginning at step **612** of **FIG. 6B**, the process begins unblocking the links of HCMIM **102**. At each link of HCMIM **102**, application **122** determines whether the currently indexed link is not failed and provisioned (step **612**). As stated above, the link index is indicated by the "m_therm_index" parameter. If the link is failed or not provisioned, the process proceeds to step **620**, described in further detail herein. Otherwise, if the link is provisioned and not failed, the process proceeds to step **622**.

[0056] At step **622**, it is determined whether the currently indexed link is currently blocked. The link may be blocked locally by an operator or blocked for other reasons due to temperature as described further herein. If the currently indexed link is blocked, the process may proceed to step **620** of **FIG. 6C**. Otherwise, if the currently indexed link is not blocked, the process proceeds to step **624**.

[0057] At step **624**, it is determined whether the "LINK_THERM_STATE" parameter for the currently indexed link is set to a "THERM_BLOCKED" condition indicating that the link is thermally blocked or a "THERM_LOCAL_OVRWRT" condition indicating that the link that is thermally blocked is also manually blocked. If the currently indexed link is thermally blocked or has a thermal local overwrite condition, the process may proceed to step **620**. Otherwise, if the currently indexed link is not blocked, the process proceeds to step **626** of **FIG. 6C**.

[0058] Next, at step **626**, a "LINK_THERM_ALARM" parameter for the currently indexed link is set to a "THERM_ALARM_UNBLK" condition for indicating to OAM **110** that the link is unblocked. Upon notification of the condition, OAM **110** can implement unblocking as described in further detail herein (step **628**). According to one embodiment, OAM **110** can call an unblocking function **214** (shown in **FIG. 2**) for unblocking the currently indexed link, as described in further detail below. In addition, OAM **110** can set up a buffer to store received message traffic during the operation of unblocking function **214**.

[0059] Next, at step **630**, it is determined whether the "x_therm_indicator" parameter is set to a "BACK_TO_NORMAL" condition indicating that the link has been unblocked. If the "x_therm_indicator" parameter is not set to the "BACK_TO_NORMAL" condition, the process proceeds to step **620**. Otherwise, the "LINK_THERM_"_STATE" parameter is set to a "THERM_NONE" condition indicating that the link which was thermally blocked is being blocked by an operator command (step **632**). Next, the process proceeds to step **620**.

[0060] Next, at step **620**, the "m_therm_index" parameter is incremented by one for indexing another link. Next, at step **634** of **FIG. 6D**, it is determined whether all of the links for this link batch have been processed. If all of the links for this link batch have not been processed, the process proceeds back to step **612** for processing the currently indexed link, associated with the "m_therm_index" parameter incre-

mented in step **620** of **FIG. 6C**. Otherwise, if all of the links for this link batch have been processed, the process proceeds to step **636**.

[**0061**] At step **636**, it is determined whether all of the thermally blocked links of HCMIM **102** have been unblocked. If all of the thermally blocked links have not been blocked, the "m_therm_index" parameter and the "THERM_UNBLOCK_FLAG" parameter are reset (step **638**). The process can then stop at step **640**.

[**0062**] If all of the thermally blocked links have been block the process proceeds to step **642** where the timer is reset to zero and started. The timer may be set to timeout at 500 ms. On the timeout of the timer at step **644**, another thermal link block event can be triggered and the process of **FIGS. 6A-6D** may be initiated to process the next batch of links. The process then stops at step **640**.

[**0063**] As stated above, blocking function **212** can be called for blocking a currently indexed link. When blocking function **212** is called, the currently indexed link can be blocked and associated thermal variables can be set. According to one embodiment, blocking function **212** is called at step **528** of **FIGS. 5A-5D**. **FIG. 7** is a flow chart illustrating a process implemented when blocking function **212** is called according to an embodiment of the subject matter described herein. Referring to **FIG. 7**, the process for blocking a currently indexed link begins at step **700** where SS7 management module **118** receives an L3 signal trigger calling blocking function **212**.

[**0064**] Next, at step **702**, a link block function ("PMTC_BLOCK_LINK") of SS7 management module **118** is called for blocking the currently indexed link. According to one embodiment, the link block function can block the link according to SS7 link changeover specifications.

[**0065**] At step **704**, the condition of the "x_therm_indicator" parameter may be determined. It is determined whether the "x_therm_indicator" parameter is set to the "THERM_ONSET" condition (step **706**). If the "x_therm_indicator" parameter is not set to the "THERM_ONSET" condition, the process proceeds to step **708** and stops. Otherwise, the process proceeds to step **710** where the port index for the currently indexed link is retrieved.

[**0066**] Next, at step **712**, the condition of the "LINK_THERM_STATE" parameter is determined. It is determined whether the condition of the "LINK_THERM_STATE" parameter is "THERM_BLOCKED" (step **714**). If the condition is not "THERM_BLOCKED", the process proceeds to step **708** and stops. Otherwise, if the condition of the "LINK_THERM_STATE" parameter is "THERM_BLOCKED", the "LINK_THERM_STATE" parameter is set to the "THERM_LOCAL_OVRWRT" condition at step **716**. Next, the process stops at step **708**.

[**0067**] As stated above, unblocking function **214** can be called for unblocking a currently indexed link. When unblocking function **214** is called, the currently indexed link can be unblocked and associated thermal variables can be set. According to one embodiment, unblocking function **214** is called at step **622** of **FIGS. 6A-6D**. **FIGS. 8A-8B** are a flow chart illustrating a process implemented when unblocking function **214** is called according to one embodiment. Referring to **FIG. 8A**, the process for blocking a currently indexed link begins at step **800** where thermal management application **122** receives an L3 signal trigger calling unblocking function **214**.

[**0068**] Next, at step **802**, a link unblock function ("PMTC_UNBLOCK_LINK") is called for blocking the currently indexed link. According to one embodiment, the link block function can block the link according to SS7 link changeover specifications. At step **804**, the port index for the currently indexed link is retrieved.

[**0069**] At step **806**, the condition of the "x_therm_indicator" parameter may be determined. It is determined whether the "x_therm_indicator" parameter is set to the "THERM_ONSET" condition or the "THERM_RESET" condition (step **808**). If the "x_therm_indicator" parameter is not set to the "THERM_ONSET" condition or the "THERM_RESET" condition, the process proceeds to step **810** and stops. If the "x_therm_indicator" parameter is set to the "THERM_ONSET" condition, the process proceeds to step **812**. If the "x_therm_indicator" parameter is set to the "THERM_RESET" condition, the process proceeds to step **814**.

[**0070**] At step **812**, the condition of the "LINK_THERM_STATE" parameter may be determined. It is determined whether the "LINK_THERM_STATE" parameter is set to "THERM_LOCAL_OVERWRT", "THERMAL_NONE", or "THERMAL_BLOCKED" (step **816** of **FIG. 8B**). If the "LINK_THERM_STATE" parameter is not set to "THERM_LOCAL_OVERWRT", "THERMAL_NONE", or "THERMAL_BLOCKED", the condition is invalid and a debug output is generated (step **818** of **FIG. 8B**) and the process stops at step **810**. The condition of "THERM_OVERWRT" indicates that the link which was thermally blocked is also now blocked by operator input. The condition of "THERMAL_NONE" indicates that the link is unblocked and an ONSET condition exists. The condition of "THERM_BLOCKED" indicates that the link which was thermally blocked is being blocked by an operator command.

[**0071**] If the "LINK_THERM_STATE" parameter is set to "THERM_LOCAL_OVERWRT", "THERMAL_NONE", or "THERMAL_BLOCKED", the "LINK_THERM_ALARM" variable is set to "THERM_ALARM_BLK" (step **820**). Next, at step **822**, blocking function **212** is called and implemented as described herein. An example of the process of blocking function **212** is described with respect to **FIG. 7**. Next, the "LINK_THERM_STATE" variable is set to "THERM_BLOCKED" (step **824**). The process then stops at step **810**.

[**0072**] Referring to step **814**, the condition of the "LINK_THERM_STATE" parameter is determined. Next, at step **826** of **FIG. 8B**, it is determined whether the condition of the "LINK_THERM_STATE" parameter is "THERM_LOCAL_OVRWRT". If the condition of the "LINK_THERM_STATE" parameter is not "THERM_LOCAL_OVRWRT", the process stops at step **810**. Otherwise, if the condition of the "LINK_THERM_STATE" parameter is "THERM_LOCAL_OVRWRT", blocking function **212** is called and implemented as described herein (step **828** of **FIG. 8B**) and then the process stops at step **810**.

[**0073**] HCMIM **102** can include an activate link function **216** for preventing an operator from activating a thermally

blocked link. Activate link function **216** can be called when SS7 management module **118** receives an L3 signal for activating a link. **FIG. 9** is a flow chart illustrating a process implemented when module **118** receives the L3 signal for activating a link of HCMIM **102** according to one embodiment. Referring to **FIG. 9**, the process for activating a link begins at step **900** where SS7 management module **118** receives an L3 signal trigger calling activate link function **216**.

[**0074**] Next, at step **902**, a link activate function ("PMTC_ACTIVATE_LINK") is called for activating the link. According to one embodiment, the link block function can block the link according to SS7 link changeover specifications.

[**0075**] At step **904**, the condition of the "x_therm_indicator" parameter may be determined. It is determined whether the "x_therm_indicator" parameter for this link is set to the "THERM_ONSET" condition (step **906**). If the "x_therm_indicator" parameter is not set to the "THERM_ONSET" condition, the process proceeds to step **908** and stops. If the "x_therm_indicator" parameter is set to the "THERM_ONSET" condition, the process proceeds to step **910**.

[**0076**] At step **910**, the port index for the currently indexed link is retrieved. Next, at step **912**, the "LINK_THERM_ALARM" parameter is set to the "THERM_ALARM_BLK" condition. At step **914**, blocking function **212** is called for blocking the currently indexed link. An exemplary process of blocking function **212** is described with respect to **FIG. 7**. Next, at step **916**, the "LINK_THERM_STATE" parameter for the link is set to the "THERM_BLOCKED" condition. The process then stops at step **908**.

[**0077**] **FIG. 10** is a flow chart illustrating a process for indicating to OAM **110** that a block or unblock has occurred according to an embodiment of the subject matter described herein. Referring to **FIG. 10**, the process can begin at step **1000** when a pass in message buffer for TLAC has information for a port to be processed on. Next, the process proceeds to step **1002** on a "MGMT_TLAC_BLOCK_LNK" event, or to step **1004** on a "MGMT_TLAC_UNBLOCK_LNK" event.

[**0078**] At step **1006**, the condition of the "LINK_THERM_ALARM" parameter can be determined. Next, at step **1008**, it can be determined whether the "LINK_THERM_ALARM" parameter is set to the "THERM_ALARM_BLK" condition. If the "LINK_THERM_ALARM" parameter is set to "THER_ALARM_BLK", an event is generated for reporting that the link is thermally blocked (step **1010**) and the process stops (step **1012**). Otherwise, if the "LINK_THERM_ALARM" parameter is not "THER_ALARM_BLK", an event is generated for reporting that the link is thermally blocked (step **1014**) and the process stops (step **1012**).

[**0079**] At step **1016**, the condition of the "LINK_THERM_ALARM" parameter can be determined. Next, at step **1018**, it can be determined whether the "LINK_THERM_ALARM" parameter is "THERM_ALARM_UNBLK". If the "LINK_THERM_ALARM" parameter is "THER_ALARM_UNBLK", an event is generated for reporting that the link is thermally unblocked (step **1020**) and the process stops (step **1012**). Otherwise, if the "LINK_THERM_ALARM" parameter is not "THER_ALARM_UNBLK", an event is generated for reporting that the link is thermally unblocked (step **1014**) and the process stops (step **1022**). The process can stop at step **1024**.

[**0080**] As described herein, the subject matter described herein can prevent or reduce the effect of the thermal shutdown on a network interface device. Particularly, the effect of the shutdown on message traffic to and from the network interface device can be prevented or reduced. According to one embodiment, the methods, systems, and computer program products described herein can be utilized for thermal management of a network interface. The method can include sending and receiving message traffic using a processor located on a first network interface. In addition, the method can include determining a temperature level associated with the processor. The method can also include switching message traffic from the first network interface to a second network interface in response to the temperature level of the processor having a predetermined relationship with respect to a threshold value, the threshold value being less than a thermal shutdown level of the processor.

[**0081**] It will be understood that various details of the subject matter described herein may be changed without departing from the scope of the subject matter described herein. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation, as the subject matter described herein is defined by the claims as set forth hereinafter.

What is claimed is:

1. A method for thermal management of a processor associated with a network interface, the method comprising:

(a) sending and receiving message traffic using a first processor associated with a first network interface;

(b) determining a temperature associated with the first processor; and

(c) switching the message traffic from the first processor to a second processor in response to the temperature associated with the first processor having a predetermined relationship with respect to a threshold value, the threshold value being less than a thermal shutdown level of the first processor.

2. The method of claim 1 wherein sending and receiving message traffic comprises sending and receiving message traffic over a signaling system 7 (SS7) link.

3. The method of claim 1 wherein sending and receiving message traffic comprises sending and receiving message traffic over an Internet protocol (IP) link.

4. The method of claim 1 wherein the first and second processors are located on the same network interface module.

5. The method of claim 1 wherein the first and second processors are located on different network interface modules.

6. The method of claim 1 wherein switching the message traffic to the second processor includes switching traffic to a second network interface associated with the second processor.

7. The method of claim 1 wherein the first network interface comprises a telecommunications signaling link interface for sending and receiving telecommunications signaling messages and wherein the first and second processors

are configured to control the sending and receiving of the telecommunications signaling messages.

8. The method of claim 1 wherein the first network interface comprises an IP telephony network interface for sending and receiving voice packets over an IP network and wherein the first and second processors are configured to control the sending and receiving of the voice packets.

9. The method of claim 1 wherein switching the message traffic includes redirecting the message traffic from the first processor to the second processor in response to the temperature associated with the first processor being greater than the threshold value.

10. The method of claim 1 wherein step (c) comprises switching message traffic from the first processor to the second processor while the temperature of the first processor is greater than the threshold value.

11. The method of claim 1 comprising allowing provisioning links associated with the first network interface while the temperature associated with the first processor is greater than the threshold value and marking the links as unavailable for traffic.

12. The method of claim 1 comprising, after step (c), redirecting the message traffic from the second processor to the first processor in response to the temperature associated with the first processor being less than the threshold value.

13. The method of claim 12 comprising delaying of the switching of the message traffic from the second processor to the first processor for a predetermined time period after the temperature associated with the first processor falls below the threshold value.

14. The method of claim 1 comprising generating an alarm in response to the temperature associated with the first processor being greater than the threshold value.

15. A network communications device comprising:

(a) a first network interface for sending and receiving message traffic over a network;

(b) a first processor associated with the first network interface for controlling the sending and receiving of the message traffic over the first network interface;

(c) a second processor configured to control the sending and receiving of message traffic over a network;

(d) a temperature sensor for sensing a temperature associated with the first processor; and

(e) a thermal management application associated with the temperature sensor and the first processor for determining whether the temperature has a predetermined relationship with respect to a threshold value, and, in response to the temperature having a predetermined relationship with respect to the threshold value, switching the message traffic from the first processor to the second processor.

16. The network communications device of claim 15 wherein the first network interface sends and receives message traffic over a signaling system 7 (SS7) link.

17. The network communications device of claim 15 wherein the first network interface sends and receives message traffic over an Internet protocol (IP) link.

18. The network communications device of claim 15 wherein the first and second processors are located on the same network interface module.

19. The network communications device of claim 15 wherein the first and second processors are located on different network interface modules.

20. The network communications device of claim 15 comprising a second network interface associated with the second processor, wherein, in response to the temperature having the predetermined relationship with respect to the threshold value, the thermal management application is adapted to switch the message traffic from the first network interface to the second network interface.

21. The network communications device of claim 15 wherein the first network interface comprises a telecommunications signaling link interface for sending and receiving telecommunications signaling messages and wherein the first and second processors are configured to control the sending and receiving of the telecommunications signaling messages.

22. The network communications device of claim 15 wherein the first network interface comprises an IP telephony network interface for sending and receiving voice packets over an IP network and wherein the first and second processors are configured to control the sending and receiving of the voice packets.

23. The network communications device of claim 15 wherein the thermal management application is operable to redirect the message traffic from the first processor to the second processor in response to the temperature measured by the temperature sensor being greater than the threshold value.

24. The network communications device of claim 15 wherein the thermal management application is operable to switch message traffic from the first network interface to the second network interface while the temperature measured by the temperature sensor is greater than the threshold value.

25. The network communications device of claim 15 wherein the thermal management application is operable to allow an operator to provision links associated with the first network interface while the temperature measured by the temperature sensor is greater than the threshold value and to mark the links as unavailable for traffic.

26. The network communications device of claim 15 wherein the thermal management application is operable to redirect the message traffic from the second processor to the first processor in response to the temperature measured by the temperature sensor being less than the threshold value.

27. The network communications device of claim 26 wherein the thermal management application is operable to delay of the switching of the message traffic from the second processor to the first processor for a predetermined time period after the temperature measured by the temperature sensor falls below the threshold value.

28. The network communications device of claim 15 wherein the threshold value is less than thermal shutdown level of the processor.

29. The network communications device of claim 15 wherein thermal management application is adapted to generate an alarm in response to the temperature measured by the temperature sensor being greater than the threshold value.

30. A computer program product comprising computer executable instructions embodied in a computer readable medium for performing steps comprising:

(a) sending and receiving message traffic using a first processor associated with a first network interface;

(b) determining a temperature associated with the first processor; and

(c) switching the message traffic from the first processor to a second processor in response to the temperature associated with the first processor having a predetermined relationship with respect to a threshold value, the threshold value being less than a thermal shutdown level of the first processor.

31. The computer program product of claim 30 wherein the first and second processors are located on the same network interface module.

32. The computer program product of claim 30 wherein the first and second processors are located on different network interface modules.

33. The computer program product of claim 30 wherein switching the message traffic to the second processor includes switching traffic to a second network interface associated with the second processor.

34. The computer program product of claim 30 wherein the first network interface comprises a telecommunications signaling link interface for sending and receiving telecommunications signaling messages and wherein the first and second processors are configured to control the sending and receiving of the telecommunications signaling messages.

35. The computer program product of claim 30 wherein the first network interface comprises an IP telephony network interface for sending and receiving voice packets over an IP network and wherein the first and second processors are configured to control the sending and receiving of the voice packets.

36. The computer program product of claim 30 wherein switching the message traffic includes redirecting the message traffic from the first processor to the second processor in response to the temperature associated with the first processor being greater than the threshold value.

37. The computer program product of claim 30 wherein step (c) comprises switching message traffic from the first processor to the second processor while the temperature of the first processor is greater than the threshold value.

38. The computer program product of claim 30 comprising allowing provisioning links associated with the first network interface while the temperature associated with the first processor is greater than the threshold value and marking the links as unavailable for traffic.

39. The computer program product of claim 30 comprising, after step (c), redirecting the message traffic from the second processor to the first processor in response to the temperature associated with the first processor being less than the threshold value.

40. The computer program product of claim 39 comprising delaying of the switching of the message traffic from the second processor to the first processor for a predetermined time period after the temperature associated with the first processor falls below the threshold value.

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