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(54) **ON-BOARD NETWORK SYSTEM**

(71) Applicant: **DENSO CORPORATION**, Kariya-city (JP)

(72) Inventors: **Takahiro Sasaki**, Kasugai-shi (JP); **Tomohisa Kishigami**, Obu-shi (JP); **Tomoko Kodama**, Kariya-shi (JP)

(73) Assignee: **DENSO CORPORATION**, Kariya-city (JP)

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USPC **713/323**

(57) **ABSTRACT**

An on-board network system is presented. The on-board network system sends a sleep-entered message to a communication bus. The sleep-entered message is sent under a condition that a sleep condition is satisfied on a basis that a network management (NM) message is ceased during state transition process in which node's state transfers from a normal state to a power-saving state. A monitoring ECU corresponding to a master performs an abnormality detection process. In the abnormality detection process, the monitoring ECU detects an abnormality state of the state transition process based on whether or not the sleep-entered message is sent from any one of nodes, thereby it is possible to detect the abnormality state not only during each node is a normal state but also during a bus-sleep state.

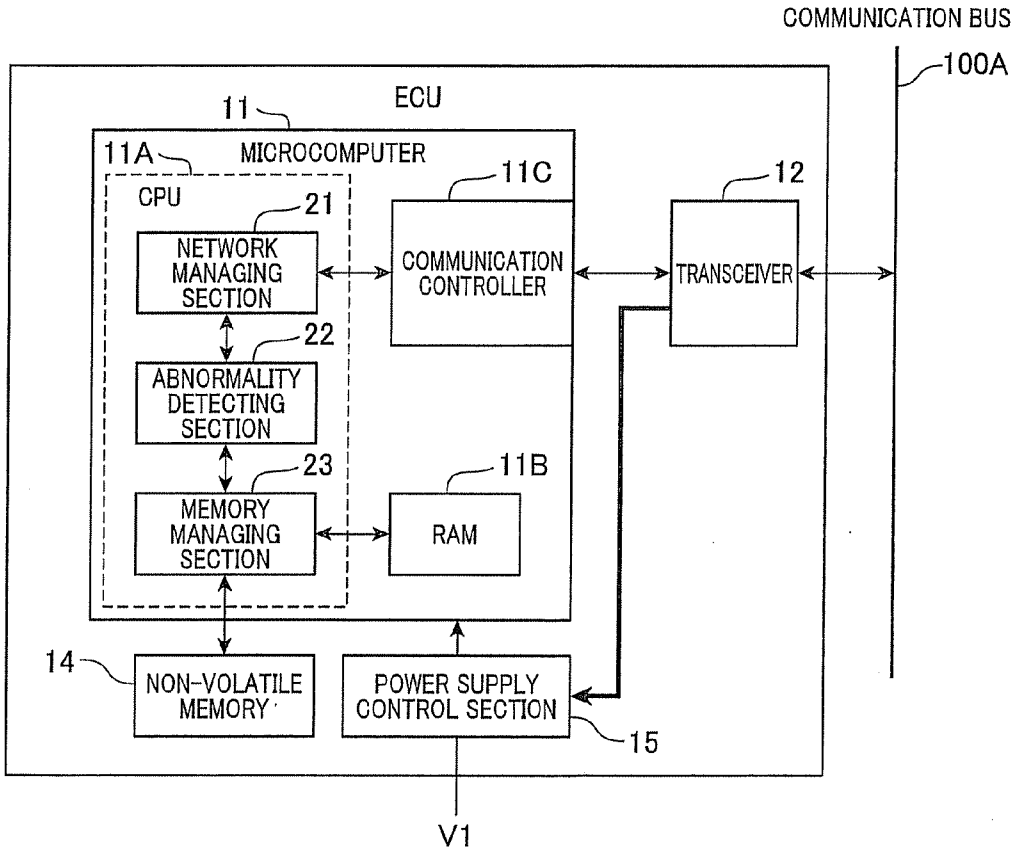


FIG.1

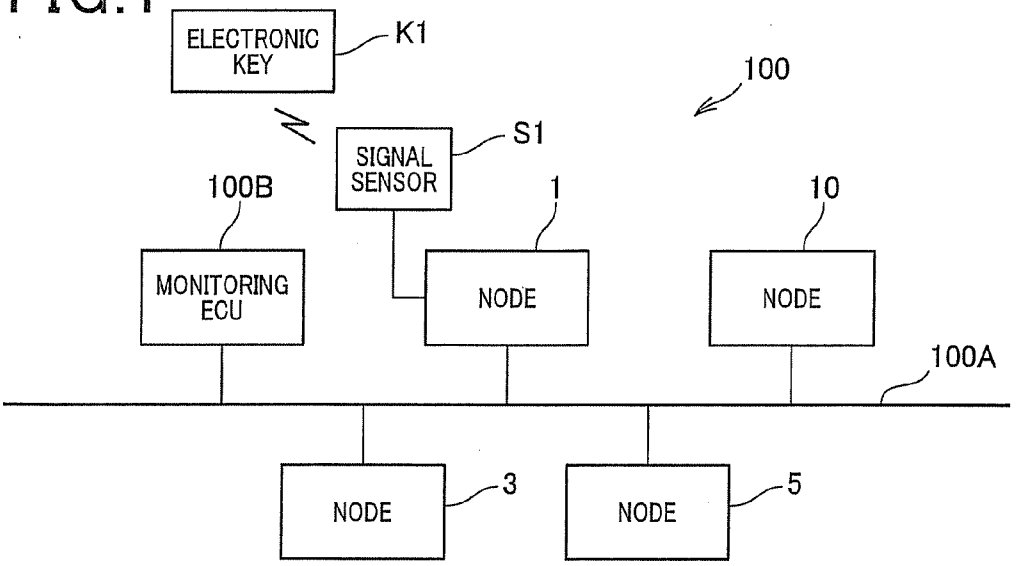

ELECTRONIC KEY
K1
100
SIGNAL SENSOR
S1
100B
1
10
MONITORING ECU
NODE
NODE
100A
NODE
3
NODE
5

FIG.2

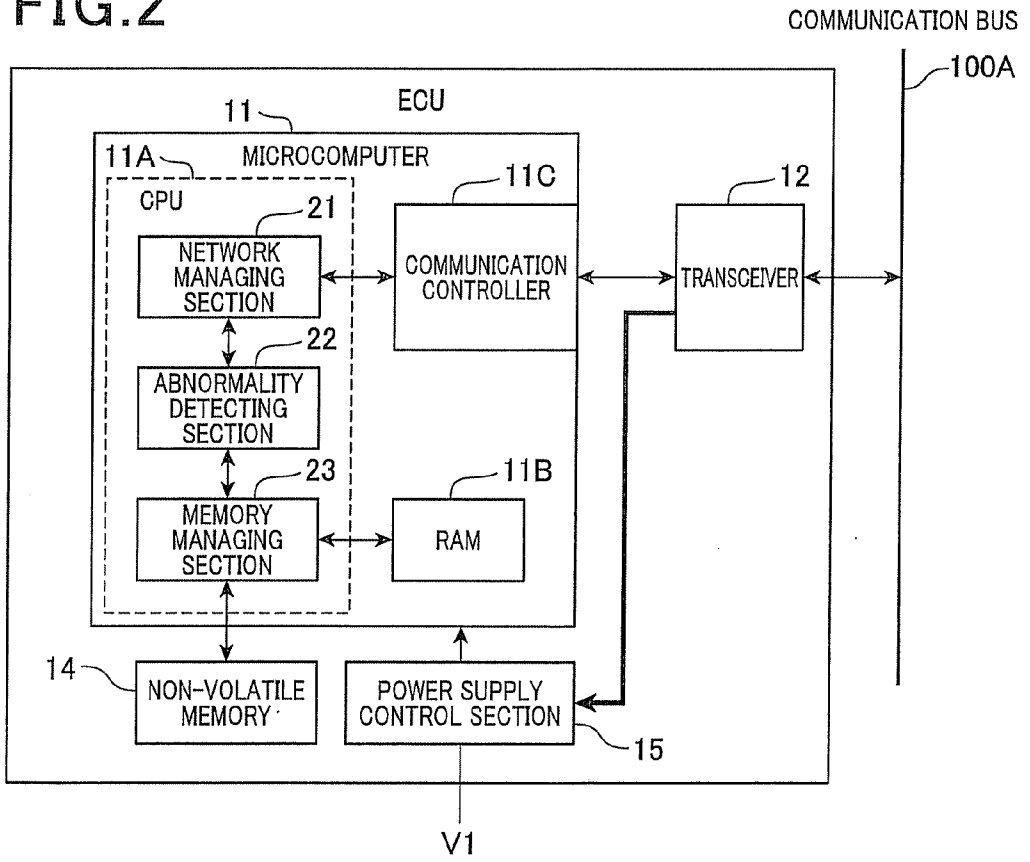

COMMUNICATION BUS
100A
ECU
11
11A
MICROCOMPUTER
CPU
21
NETWORK MANAGING SECTION
11C
COMMUNICATION CONTROLLER
12
TRANSCEIVER
22
ABNORMALITY DETECTING SECTION
23
11B
MEMORY MANAGING SECTION
RAM
14
NON-VOLATILE MEMORY
POWER SUPPLY CONTROL SECTION
15
V1

FIG.3

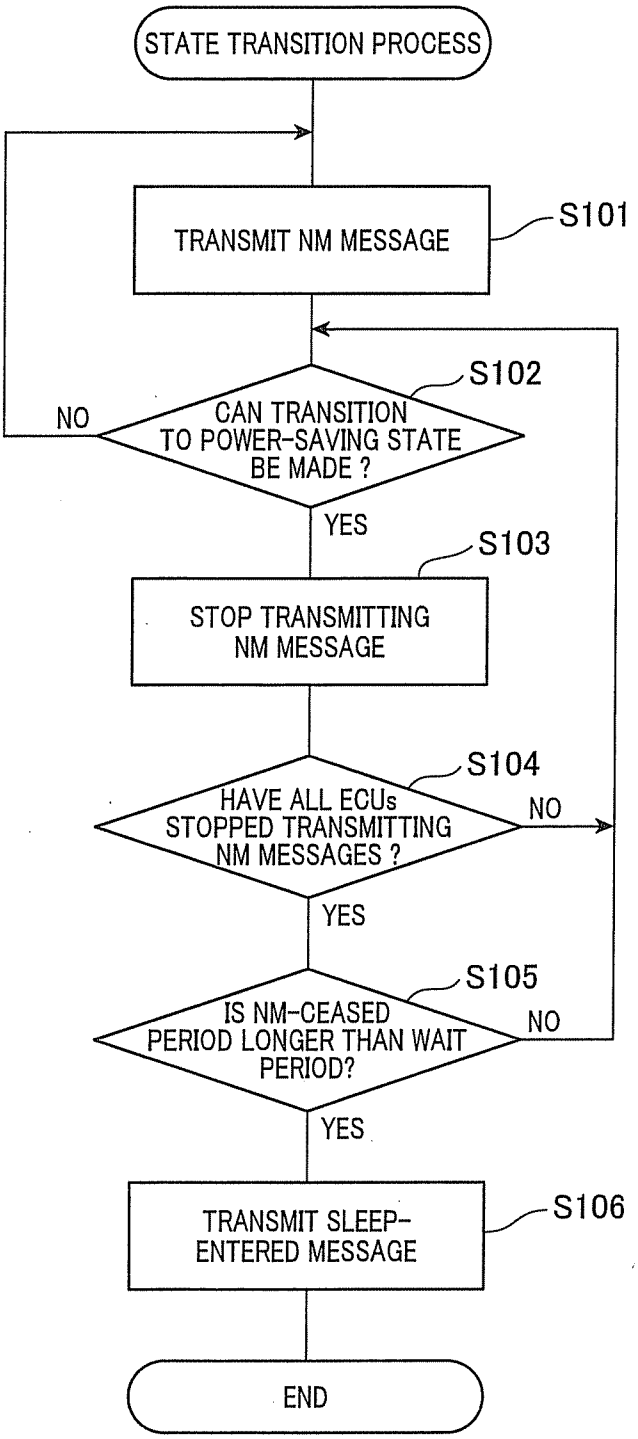

STATE TRANSITION PROCESS
TRANSMIT NM MESSAGE
S101
S102
CAN TRANSITION TO POWER-SAVING STATE BE MADE ?
NO
YES
S103
STOP TRANSMITTING NM MESSAGE
S104
HAVE ALL ECUs STOPPED TRANSMITTING NM MESSAGES ?
NO
YES
S105
IS NM-CEASED PERIOD LONGER THAN WAIT PERIOD?
NO
YES
TRANSMIT SLEEP-ENTERED MESSAGE
S106
END

FIG.4A

INDEX	NODE ID
0	1
1	3
2	5
3	10
4	12

31

FIG.4B

INDEX	RECEPTION OF SLEEP-ENTERED MESSAGE
0	1
1	0
2	0
3	1
4	1

32

1 : RECEIVED, 0 : NOT RECEIVED

FIG.5

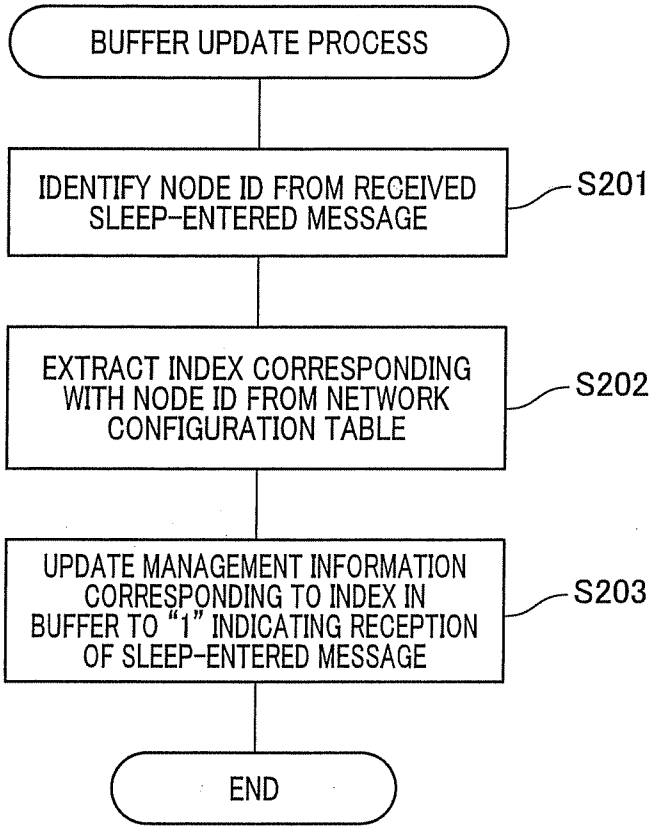

BUFFER UPDATE PROCESS
IDENTIFY NODE ID FROM RECEIVED SLEEP-ENTERED MESSAGE
S201
EXTRACT INDEX CORRESPONDING WITH NODE ID FROM NETWORK CONFIGURATION TABLE
S202
UPDATE MANAGEMENT INFORMATION CORRESPONDING TO INDEX IN BUFFER TO "1" INDICATING RECEPTION OF SLEEP-ENTERED MESSAGE
S203
END

FIG.6

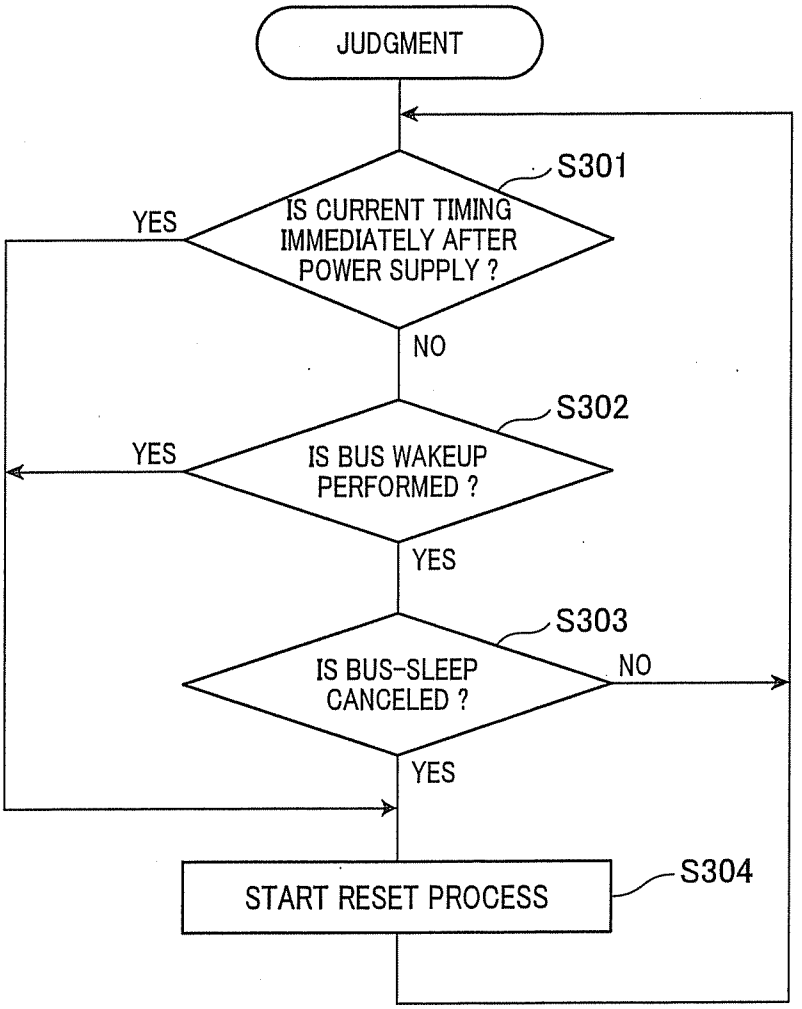

JUDGMENT
S301
IS CURRENT TIMING IMMEDIATELY AFTER POWER SUPPLY ?
YES
NO
S302
IS BUS WAKEUP PERFORMED ?
YES
YES
S303
IS BUS-SLEEP CANCELED ?
NO
YES
START RESET PROCESS
S304

FIG.7

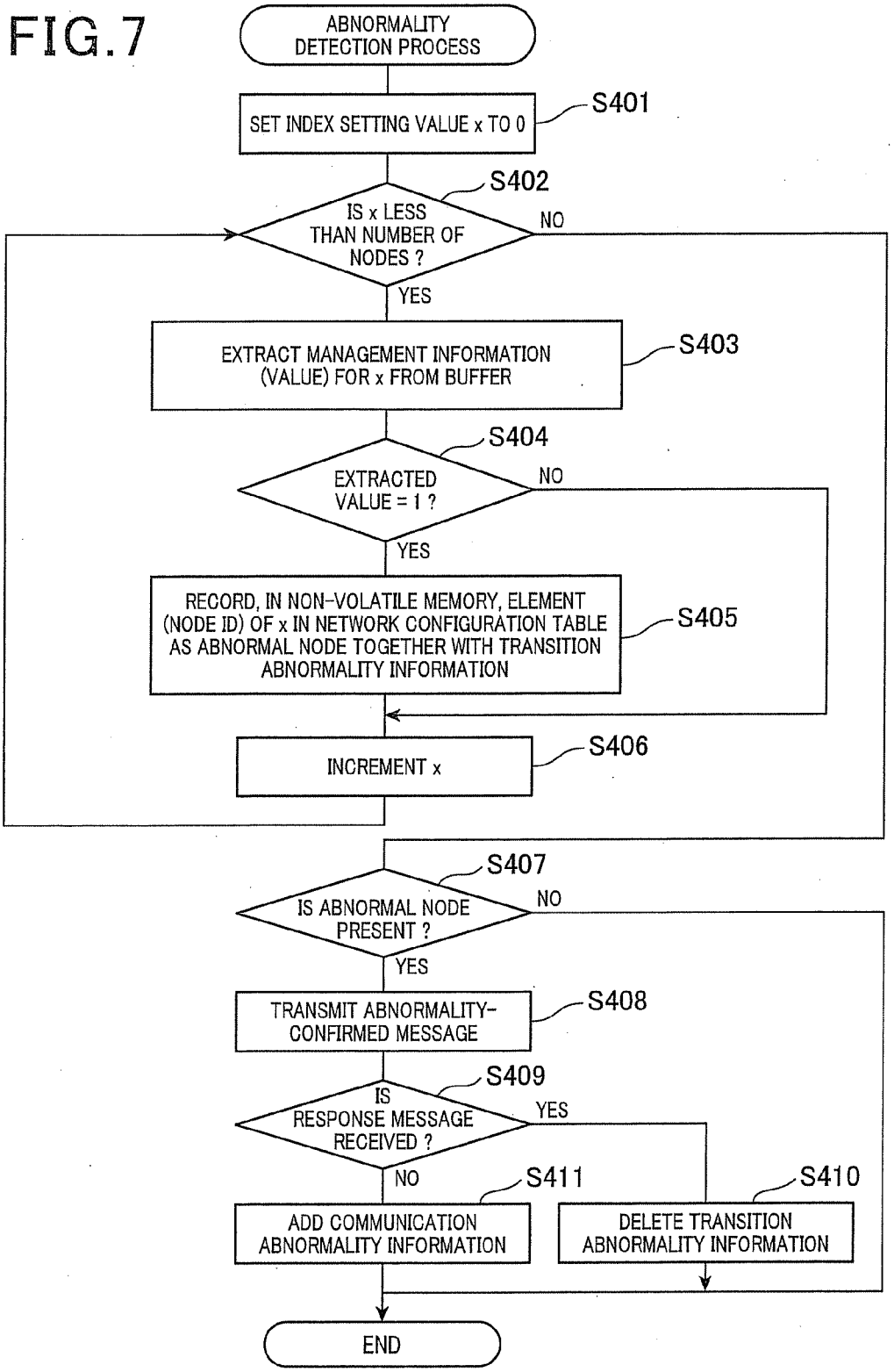

ABNORMALITY DETECTION PROCESS
SET INDEX SETTING VALUE x TO 0
S401
S402
IS x LESS THAN NUMBER OF NODES ?
NO
YES
EXTRACT MANAGEMENT INFORMATION (VALUE) FOR x FROM BUFFER
S403
S404
EXTRACTED VALUE = 1 ?
NO
YES
RECORD, IN NON-VOLATILE MEMORY, ELEMENT (NODE ID) OF x IN NETWORK CONFIGURATION TABLE AS ABNORMAL NODE TOGETHER WITH TRANSITION ABNORMALITY INFORMATION
S405
INCREMENT x
S406
S407
IS ABNORMAL NODE PRESENT ?
NO
YES
TRANSMIT ABNORMALITY-CONFIRMED MESSAGE
S408
S409
IS RESPONSE MESSAGE RECEIVED ?
YES
NO
S411
ADD COMMUNICATION ABNORMALITY INFORMATION
S410
DELETE TRANSITION ABNORMALITY INFORMATION
END

FIG.8

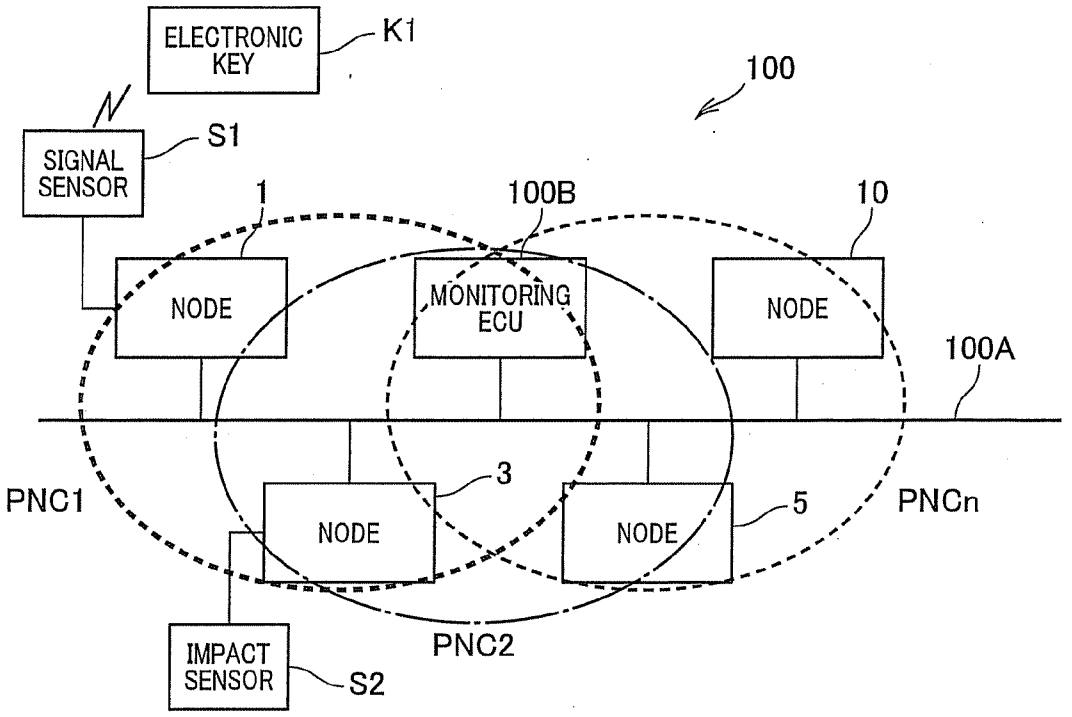

ELECTRONIC KEY
K1
100
SIGNAL SENSOR
S1
1
100B
10
NODE
MONITORING ECU
NODE
100A
PNC1
3
5
PNCn
NODE
NODE
PNC2
IMPACT SENSOR
S2

FIG.9A

31

INDEX	NODE ID	PNC1	PNC2	···	PNCn
0	1	1	0	···	0
1	3	1	1	···	0
2	5	0	1	···	1
3	10	0	0	···	1

n : NUMBER OF PN SYSTEMS PRESENT IN ON-BOARD NETWORK SYSTEM
PNCn VALUE :
1 : BELONGS TO PNCn
0 : DOES NOT BELONG TO PNCn

FIG.9B

32

INDEX	RECEPTION OF SLEEP-ENTERED MESSAGE
0	PNC1 (SUBJECT IDENTIFIER)···1(MANAGEMENT INFORMATION)
1	PNC1···1, PNC2···0
2	PNC2···0, PNCn···1
3	PNCn···1

1 : RECEIVED, 0 : NOT RECEIVED

FIG.10

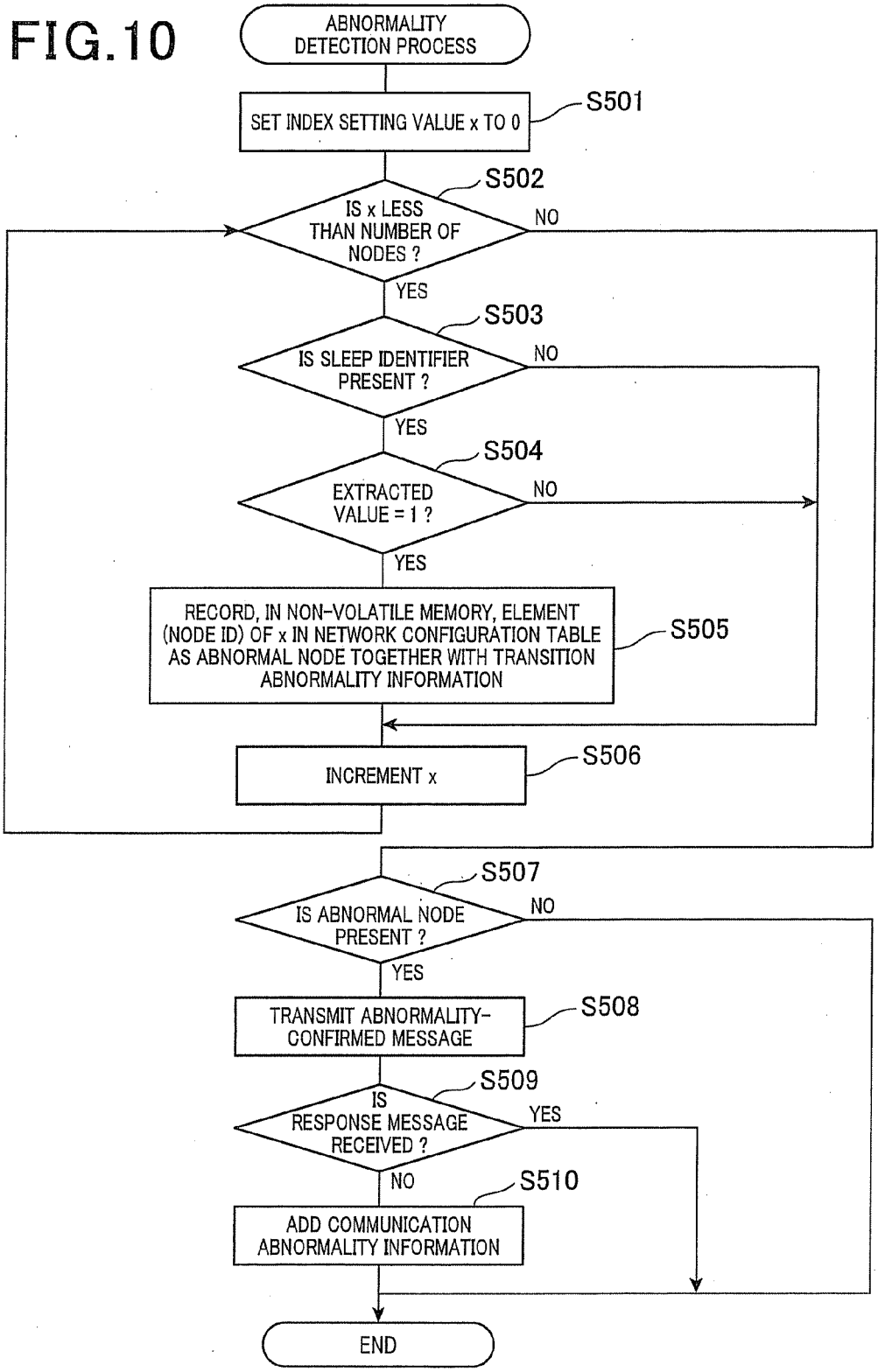

ABNORMALITY DETECTION PROCESS
SET INDEX SETTING VALUE x TO 0
S501
S502
IS x LESS THAN NUMBER OF NODES ?
NO
YES
S503
IS SLEEP IDENTIFIER PRESENT ?
NO
YES
S504
EXTRACTED VALUE = 1 ?
NO
YES
RECORD, IN NON-VOLATILE MEMORY, ELEMENT (NODE ID) OF x IN NETWORK CONFIGURATION TABLE AS ABNORMAL NODE TOGETHER WITH TRANSITION ABNORMALITY INFORMATION
S505
INCREMENT x
S506
S507
IS ABNORMAL NODE PRESENT ?
NO
YES
TRANSMIT ABNORMALITY-CONFIRMED MESSAGE
S508
S509
IS RESPONSE MESSAGE RECEIVED ?
YES
NO
S510
ADD COMMUNICATION ABNORMALITY INFORMATION
END

FIG.11

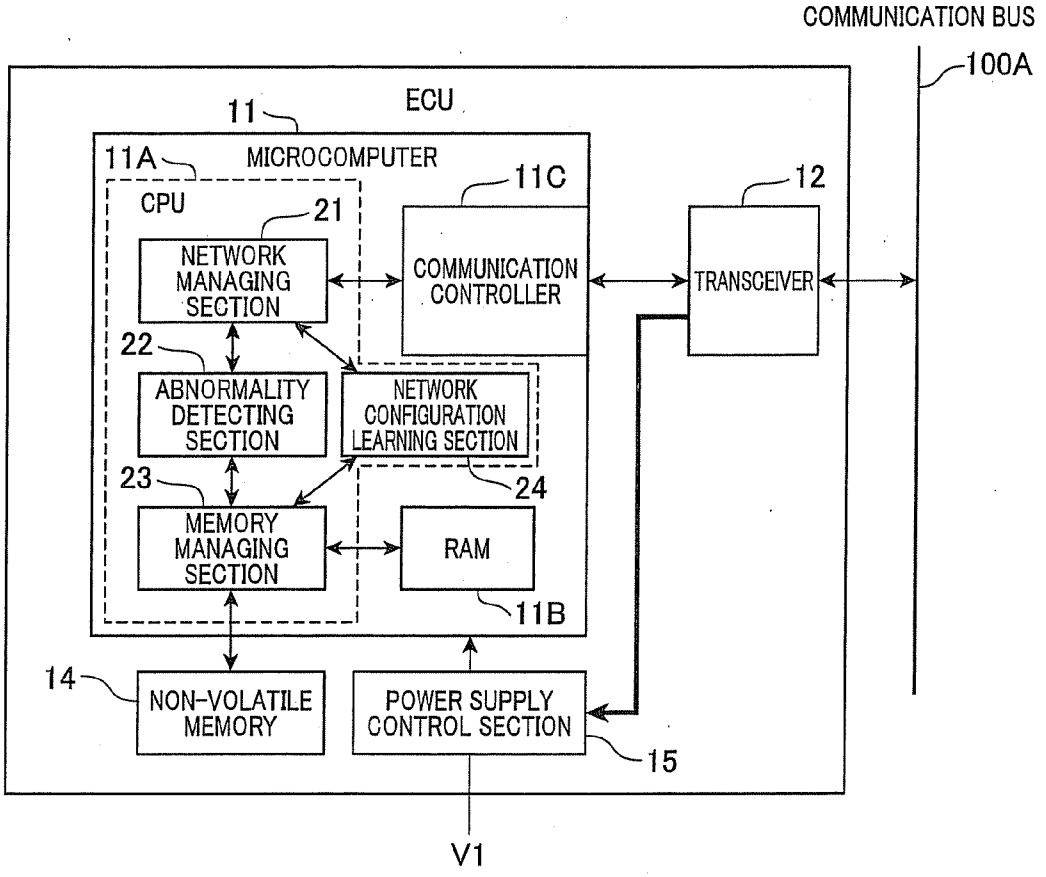
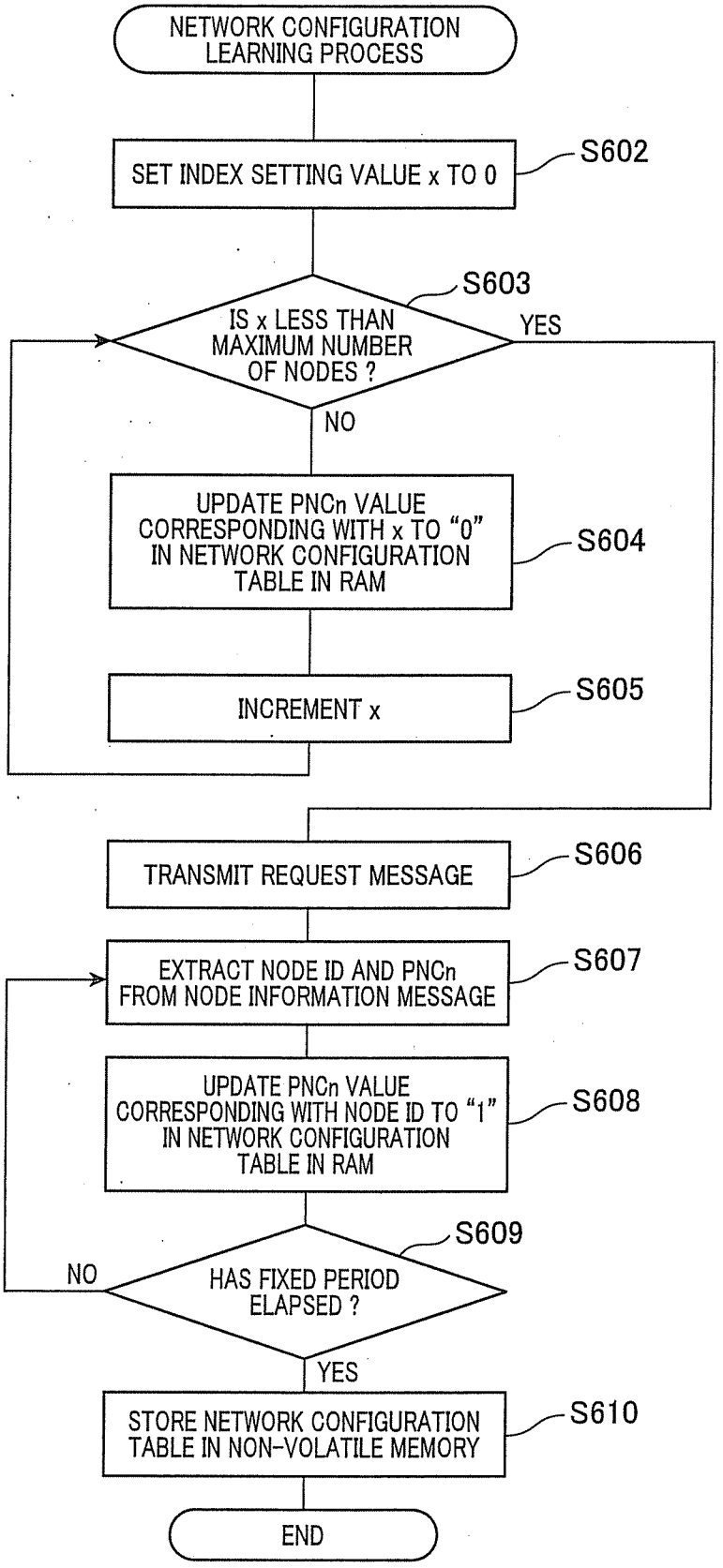

COMMUNICATION BUS
100A
ECU
11
11A
MICROCOMPUTER
CPU
21
NETWORK MANAGING SECTION
11C
COMMUNICATION CONTROLLER
12
TRANSCEIVER
22
ABNORMALITY DETECTING SECTION
NETWORK CONFIGURATION LEARNING SECTION
24
23
MEMORY MANAGING SECTION
RAM
11B
14
NON-VOLATILE MEMORY
POWER SUPPLY CONTROL SECTION
15
V1

FIG.12


NETWORK CONFIGURATION LEARNING PROCESS
SET INDEX SETTING VALUE x TO 0
S602
IS x LESS THAN MAXIMUM NUMBER OF NODES ?
S603
YES
NO
UPDATE PNCn VALUE CORRESPONDING WITH x TO "0" IN NETWORK CONFIGURATION TABLE IN RAM
S604
INCREMENT x
S605
TRANSMIT REQUEST MESSAGE
S606
EXTRACT NODE ID AND PNCn FROM NODE INFORMATION MESSAGE
S607
UPDATE PNCn VALUE CORRESPONDING WITH NODE ID TO "1" IN NETWORK CONFIGURATION TABLE IN RAM
S608
HAS FIXED PERIOD ELAPSED ?
S609
NO
YES
STORE NETWORK CONFIGURATION TABLE IN NON-VOLATILE MEMORY
S610
END

ON-BOARD NETWORK SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based on and claims the benefit of priority from earlier Japanese Patent Application No. 2012-178171 filed Aug. 10, 2012, the description of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Technical Field

[0003] The present invention relates to an on-board network system comprising a plurality of electronic control units that are communicably connected with each other over a communication bus to share control messages accompanying control of on-board devices mounted in a vehicle, and providing a network management function.

[0004] 2. Description of the Related Art

[0005] Conventionally, numerous electronic control units (ECUs) are mounted in a vehicle to control on-board devices. An on-board network system includes the ECUs being disposed on a communication bus.

[0006] In an on-board network system such as this, each ECU transmits control messages to the communication bus. The control messages include various detection values indicating the state of the vehicle, commands issued to the on-board devices, and the like. The control messages are shared among other ECUs, thereby actualizing efficient and comprehensive vehicle control.

[0007] In addition, in the on-board network system, a network management (NM) function is being reinforced in accompaniment with the increase in the number of ECUs mounted in the vehicle. Here, the NM function is provided to manage whether nor not each ECU is operating normally. The operations of the ECU include a so-called bus-sleep operation. In the bus-sleep operation, when control messages are not required to be transmitted and received over the communication bus, each ECU transitions, for example, its own communication controller and transceiver to power-saving mode, thereby transitioning from a "normal state" to a "power-saving state", to suppress power consumption of the overall system.

[0008] In addition, as a working of the bus-sleep operation, a situation is known in which, in the normal state, each ECU periodically transmits a network management (NM) message indicating that transition to the power-saving state is not possible. When transition to the power-saving state becomes possible, the ECU ceases transmission of the NM message. In addition, when the NM messages from other ECUs are no longer received, the ECU transitions from the normal state to the power-saving state.

[0009] In other words, when each ECU is no longer required to use the communication bus for itself and is no longer required to use the communication bus for the other ECUs, control messages are no longer required to be transmitted and received. Therefore, the ECU transitions from the normal state to the power-saving state. In some instances, in addition to the communication controller and transceiver of the ECU entering power-saving mode, power supply to the microcomputer of the ECU may also be stop. Power supply to the microcomputer being stopped in this way is referred to as microcomputer-sleep.

[0010] In this type of on-board network system, a system is known in which an ECU (relay device) that relays the transmission and reception of control messages between a plurality of communication buses monitors the operating state of other ECUs (nodes). Depending on whether the node that is the transmission source is in the normal state or the power-saving state, the ECU (relay device) relays or stops relaying the NM messages (for example, refer to JP-A-2011-87112).

[0011] However, in the conventional on-board network system, the operating state of a node is judged only based on whether or not the NM message has been received. Therefore, a problem occurs in that it cannot be determined whether the node has ceased transmitting the NM message because of a normal operation or is unable to transmit the NM message because of some sort of malfunction (abnormality). In other words, in the latter instance, a problem occurs in that the abnormal operation of the node cannot be favorably detected in the NM function.

[0012] Therefore, an on-board network system providing an NM function is desired that is capable of efficiently detecting operation abnormality in the system.

SUMMARY

[0013] As an exemplary embodiment, the present application provides an on-board network system including a plurality of electronic control units that are communicably connected with each other over a communication bus.

[0014] The plurality of electronic control units are configured by a plurality of common nodes (hereinafter referred to as "nodes") and a master node (hereinafter referred to as "master"). The nodes perform a state transition process for transitioning from a normal state in which control messages can be transmitted and received to a power-saving state in which control messages cannot be transmitted or received, according to a sleep condition set in advance. The master performs an abnormality detection process for detecting an abnormality related to the state transition process for each node.

[0015] In a configuration such as this, each node periodically transmits a network management (NM) message to the communication bus. The NM message indicates that the node itself is unable to transition to the power-saving mode. When the node is able to transition to the power-saving mode, the node itself ceases transmitting the NM message. In addition, when a period (hereinafter referred to as "NM-ceased period") during which NM messages are not received from other electronic control units over the communication bus exceeds a wait period set in advance, the sleep condition is met.

[0016] In the state transition process performed by each node, when the sleep condition is met, the node transmits a sleep-entered message to the communication bus. The sleep-entered message indicates that the sleep condition is met. On the other hand, in the abnormality detection process performed by the master, abnormality related to the state transition process performed by each node is detected based on whether or not the sleep-entered message has been received.

[0017] In a configuration such as this, based on whether or not a message (sleep-entered message) voluntarily transmitted by the node during a bus-sleep operation accompanying the state transition process has been received, for example, when the master receives a number of sleep-entered messages amounting to the number of nodes, the master can judge that all nodes are operating normally. When the number of sleep-

entered messages is insufficient, the master can judge that an abnormality has occurred in a node within the system.

[0018] Therefore, in the on-board network system according to the exemplary embodiment, in addition to abnormality detection while the node is in the normal state, abnormality detection during the bus-sleep operation can also be favorably performed. Therefore, operation abnormality in a system providing the NM function can be efficiently detected.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] In the accompanying drawings:

[0020] FIG. **1** shows a block diagram showing a first embodiment of an on-board network system;

[0021] FIG. **2** shows a first embodiment of a master and a node;

[0022] FIG. **3** shows a flowchart of an example of a state transition process performed by each node;

[0023] FIG. **4**A shows a first embodiment of a network configuration table, and FIG. **4**B shows a first embodiment of buffer management information;

[0024] FIG. **5** shows a flowchart of a first embodiment of processing operations in a buffer update process;

[0025] FIG. **6** shows a flowchart of a first embodiment of timing at which a buffer reset process is performed;

[0026] FIG. **7** shows a flowchart of a first embodiment of processing operations in an abnormality detection process;

[0027] FIG. **8** shows a block diagram showing a second embodiment of the on-board network system;

[0028] FIG. **9**A shows a second example of the network configuration table, and FIG. **9**B shows a second example of the buffer management information;

[0029] FIG. **10** shows a flowchart of a second embodiment of the processing operations in the abnormality detection process;

[0030] FIG. **11** shows a second embodiment of a master; and

[0031] FIG. **12** shows a flowchart of an example of processing operations in a network configuration learning process.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

[0032] An on-board network system according to a first embodiment of the present invention will hereinafter be described with reference to the FIG. **1** to FIG. **7**.

[0033] [Overall Configuration]

[0034] As shown in FIG. **1**, in an on-board network system **100**, numerous electronic control units (ECUs) mounted in a vehicle are connected by a communication bus **100**A. ECUs compose nodes **1**, **3**, **5**, **10**, and a master **100**B. The master **100**B corresponds to monitoring ECU. Each nodes **1**, **3**, **5**, **10** and a master **100**B transmits and receives control messages to and from each other over the communication bus **100**A, thereby sharing various detection values indicating the state of the vehicle, commands issued to on-board devices, and the like. The on-board network system **100** actualizes efficient and comprehensive vehicle control. The on-board devices include the ECUs, and devices and electrical equipment (referred to, hereinafter, as "controlled devices") other than the ECUs that configure the vehicle.

[0035] The on-board network system **100** also provides a network management (NM) function. Among the numerous ECUs, the monitoring ECU **100**B is included. The monitoring ECU **100**B serves as a master which monitors whether or not the other ECUs (nodes **1**, **3**, **5**, and **10**) are operating normally.

[0036] As shown in FIG. **2**, each node **1**, **3**, **5**, and **10** and the monitoring ECU **100**B (in other words, all ECUs) share a common configuration that includes a known microcomputer **11**, a transceiver **12**, a non-volatile memory **14**, and a power supply control section **15**.

[0037] The microcomputer **11** includes a central processing unit (CPU) **11**A, a random access memory (RAM) **11**B, and a communication controller **11**C. The CPU **11**A performs various processes related to vehicle control using the RAM **11**B as a work area, based on programs stored in, for example, the non-volatile memory **14**. The CPU **11**A outputs commands for operating the controlled devices to the controlled devices. The CPU **11**A also generates control messages indicating detection values inputted from the controlled devices, commands issued to the on-board devices (including other ECUs), and the like.

[0038] The communication controller **11**C transmits the control messages generated by the CPU **11**A to the communication bus **100**A based on a predetermined protocol. The communication controller **11**C also receives control messages from other ECUs over the communication bus **100**A, and transmits the control messages to the CPU **11**A. The protocol refers to communication rules for transmitting and receiving control messages among ECUs. For example, a known controller area network (CAN) protocol is used.

[0039] The transceiver **12** is connected to the communication controller **11**C and the communication bus **100**A. The transceiver **12** converts voltage signals (analog signals) flowing over the communication bus **100**A to digital data and transmits the digital data to the communication controller **11**C. The transceiver **12** also converts the control messages (digital data) transmitted from the communication controller **11**C to analog signals and transmits the analog signals to the communication bus **100**A.

[0040] The non-volatile memory **14** stores therein programs and data that should be held even when supply from a battery V**1** is interrupted. The power supply control section **15** is connected to the battery V**1** of the vehicle. The power supply control section **15** controls power supply from the battery V**1** to the microcomputer **11**.

[0041] Specifically, the power supply control section **15** is also connected to the communication bus **100**A via the transceiver **12**. For example, during microcomputer-sleep when power supply to the microcomputer **11** is stopped, when a predetermined startup signal is inputted from the communication bus **110**A via the transceiver **12**, the power supply control section **15** resumes power supply to the microcomputer **11** and transitions the communication controller **11**C and the transceiver **12** from the power-saving state to the normal state.

[0042] In the on-board network system **100** according to the first embodiment, the power supply control section **15** of each ECU is configured to perform control related to power supply as described above. Each ECU transmits the above-described startup signal as required by itself to the communication bus **100**A, thereby starting a bus wakeup operation of the other ECUs.

[0043] On the other hand, the transition of each ECU from a state in which control messages can be transmitted (normal

state) to a state in which control messages cannot be transmitted (power-saving state) will be described hereafter.

[State Transition Process]

[0044] The microcomputer **11** of each ECU performs a state transition process shown in FIG. **3**. In other words, in the normal state, the microcomputer **11** transmits a control message (corresponds to a "network management message, hereinafter referred to as "network NM message") to the communication bus **100**A at a constant interval (S**101**). The NM message indicates that the ECU itself cannot transition to the power-saving state. In other words, the microcomputer **11** transmits to the other ECUs that control may be affected should its own ECU transition to the power-saving state. Then, when a predetermined trigger is generated, the microcomputer **11** judges whether or not its own ECU can transition from the normal state to the power-saving state (step S**102**). When judged that the transition can be made ("YES" at step S**102**), the microcomputer **11** stops transmitting the NM message (step S**103**). In other words, the microcomputer **11** transmits to the other ECUs that control will not be affected even should its own ECU transition to the power-saving state. When judged at S**102** that the transition to the power-saving state cannot be made ("NO" at step S**102**), the microcomputer **11** continues performing the processing operation at step S**101**.

[0045] The microcomputer **11** waits until NM messages are no longer received from any other ECU on the communication bus **100**A (step S**104**). When judged that no NM messages are received ("YES" at step S**104**), the microcomputer **11** sets a timer and judges whether or not the period (NM-ceased period) over which no NM messages are received exceeds a wait period that is set in advance (step S**105**). When judged that the NM-ceased period exceeds the wait period ("YES" at step S**105**), the microcomputer **11** judges that the sleep condition for its own ECU is met. In other words, the sleep condition is that all other ECUs, in addition to its own ECU, are confirmed to be in a state in which the transition to the power-saving state can be made. When judged at step S**104** that an NM message has been received from any ECU ("NO" at step S**104**), the microcomputer **11** continues to perform the processing operation at step S**102**. When judged at S**105** that the NM-ceased period does not exceed the wait period ("NO" at step S**105**), the microcomputer **11** returns to step S**102**.

[0046] When judged that the NM-ceased period exceeds the wait period ("YES" at step S**105**), the microcomputer **11** of each node transmits a control message (sleep-entered message) to the communication bus **100**A (step S**106**). The sleep-entered message indicates that the sleep condition is met. The sleep-entered message includes at least a node identifier (ID) for identifying the ECU (at least the node) that is the transmission source of the message. The above-described NM message also includes the node ID. A CAN ID can be used as the node ID.

[0047] Here, a configuration in which the on-board network system **100** includes keyless entry system, such as that shown in FIG. **1**, will be described as an example. The keyless entry system includes the node **1**, the node **3**, the node **5**, and the monitoring ECU **100**B. In the node **1**, a signal sensor S**1** is connected to the microcomputer **11** of the ECU itself. The signal sensor **51** receives a wireless signal (keyless signal) from an electronic key K**1** held by the user of the vehicle. The node **3** locks and unlocks the vehicle door. The node **5** turns on the vehicle lights.

[0048] Specifically, in the keyless entry system, when the vehicle power supply is turned OFF (but the background power supply is ON at all times), power is supplied only to the signal sensor S**1** and the microcomputer **11** of the node **1**. When the vehicle power supply is turned OFF in this way and the signal sensor S**1** receives a keyless signal, the microcomputer **11** of the node **1** checks whether or not a code included in the keyless signal is legitimate. When the code is authenticated as a legitimate code, the microcomputer **11** performs a bus wakeup operation of its own node and returns to the normal state. In addition, the microcomputer **11** transmits a startup signal to the communication bus **100**A, thereby starting the bus wakeup operation of the monitoring ECU **100**B, the node **3**, the node **5**, and another node **10**. The node **10** represents nodes within the on-board network system that do not belong to the keyless entry system.

[0049] Then, when the bus wakeup operation is completed, the node **3** and the node **5** receive a control message indicating a command from the node **1**. The node **3** unlocks the door. The node **5** turns on the hazard lights as an answerback to the user of the vehicle. In addition, when the bus wakeup operation is completed, each node periodically transmits the NM message to the communication bus **100**A.

[0050] On the other hand, when the ignition switch (IG switch) of the vehicle is turned ON by the electronic key K**1**, the node **1** stops transmitting the NM message after the elapse of a predetermined period. Next, the other nodes also stop transmitting the NM message each time a predetermined trigger is generated. For example, when the IG switch switches from ON to OFF, the node **5** and the node **10** stop transmitting the NM message. When the door is locked by the electronic key K**1**, the node **3** stops transmitting the NM message.

[0051] When all ECUs stop transmitting the NM messages in this way, the sleep condition is met. Each node transmits the sleep-entered message including the node ID corresponding to itself to the communication bus **100**A and transitions from the normal state to the power-saving state.

[Configuration of the Monitoring ECU]

[0052] Next, the differences with the other nodes in the configuration of the monitoring ECU **100**B will be described.

[0053] As shown in FIG. **2**, the CPU **11**A of the monitoring ECU **100**B includes, when functionally divided, a network managing section **21**, an abnormality detecting section **22**, and a memory managing section **23**. The network managing section **21** transmits and receives the control messages to and from the communication controller **11**C. The abnormality detecting section **22** detects an abnormal operation in the nodes. The memory managing section **23** manages the RAM **11**B and the non-volatile memory **14**.

[0054] In addition, as shown in FIG. **4**A, the non-volatile memory **14** stores therein a network configuration table **31** in which indexes indicating addresses within a memory in the RAM **11**B and node IDs are associated.

[0055] On the other hand, as shown in FIG. **4**B, the RAM **11**B is provided with a buffer **32** that serves as an area for temporarily storing management information indicating whether or not a sleep-entered message has been received for each index.

[0056] [Buffer Update Process]

[0057] Here, a buffer update process performed by the CPU **11**A of the monitoring ECU **100**B as a function of the memory managing section **23** will be described with reference to the flowchart in FIG. **5**.

[0058] When the buffer update process is started, first, based on the sleep-entered message received by the network managing section **21**, the memory managing section **23** identifies the node ID included in the message (step S**201**). Then, the memory managing section **23** extracts the index associated with the node ID identified at step S**201** from the network configuration table **31** (step S**202**). Next, the memory managing section **23** rewrites the management information corresponding to the index extracted at step S**202** in the buffer **32** from 0 (zero) indicating that the sleep-entered message has not been received to 1 indicating that the sleep-entered message has been received, thereby updating the buffer **32** (step S**203**).

[Buffer Reset Process]

[0059] The memory managing section **23** performs a process (buffer reset process) for resetting the buffer **32** in preparation for the bus sleep in the on-board network system **100**. The judgment regarding the timing at which the CPU **11**A of the monitoring ECU **100**B performs the buffer reset process as a function of the memory managing section **23** will be described with reference to the flowchart in FIG. **6**.

[0060] As shown in FIG. **6**, the memory managing section **23** judges whether or not the current timing is immediately after power supply to the microcomputer **11** (step S**301**). When judged that the current timing is immediately after power supply to the microcomputer **11** ("YES" at step S**301**), the memory managing section **23** starts the buffer restart process.

[0061] In addition, after the bus sleep of the on-board network system **100** is confirmed based on the result of the above-described buffer update process, the memory managing section **23** judges whether or not at least one node has performed the bus wakeup operation based on whether or not the NM message has been received (step S**302**). When judged that a bus wakeup such as this is detected ("YES" at step step S**302**), the memory managing section **23** starts the buffer reset process.

[0062] In addition, the memory managing section **23** judges whether or not a node is present that performs an operation (bus-sleep cancel operation) to terminate the above-described state transition process by a predetermined trigger after transmitting the sleep-entered message, based on, for example, whether not a node that performs re-transmission of the NM message is present during the above-described NM-ceased period (step S**303**). When judged that a bus-sleep cancelation such as this is detected ("YES" at step S**303**), the memory managing section **23** starts the buffer reset process.

[0063] When the buffer reset process is started, all pieces of management information within the buffer **32** are reset to 0 (zero).

[Abnormality Detection Process]

[0064] Next, an abnormality detection process performed by the CPU **11**A of the monitoring ECU **100**B as a function of the abnormality detecting section **22** will be described with reference to the flowchart in FIG. **7**. The abnormality detection process is started when a sleep completion period has elapsed. The sleep completion period, which is set in advance, is a period until all nodes **1**, **3**, **5**, and **10** complete the state transition process after the network managing section **21** has received at least one sleep-entered message.

[0065] When the abnormality detection process is started, first, the abnormality detecting section **22** sets an index value (x=0) indicating the head address in the buffer **32** (step S**401**). Next, the abnormality detecting section **22** judges whether or not the index setting value x is smaller than a value corresponding to the total number of nodes (step S**402**). When judged "YES" at step S**402**, the abnormality detecting section **22** proceeds to step S**403**. When judged "NO" at step S**402**, the abnormality detecting section **22** proceeds to step S**407**, described hereafter.

[0066] At step S**403**, the abnormality detecting section **22** extracts the management information corresponding to the index setting value x from the buffer **32**. Then, the abnormality detecting section **22** judges whether or not the management information extracted at step S**403** is 1 indicating that the sleep-entered message has been received (step S**404**). Here, when judged "NO" at step S**404**, the abnormality detecting section **22** proceeds to step S**406**. When judged "YES" at step S**404**, the abnormality detecting section **22** proceeds to step S**405**. In other words, when judged that the management information extracted at step S**403** is 0 (zero) indicating that the sleep-entered message has not been received, the abnormality detecting section **22** proceeds to step S**406**.

[0067] At step S**405**, the abnormality detecting section **22** records, in the non-volatile memory **14**, the node ID corresponding with the index setting value x in the network configuration table **31** together with information (transition abnormality information) indicating that the node is a node (abnormal node) having at least an abnormality related to the state transition process. On the other hand, the abnormality detecting section **22** increments the index setting value x at step S**406** and returns to step S**402**.

[0068] At step S**407**, the abnormality detecting section **22** judges whether or not an abnormal node is detected in the processing operations at step S**401** to S**406**. When judged "YES" at step S**407**, the abnormality detecting section **22** proceeds to step S**408**. When judged NO at step S**407**, the abnormality detecting section **22** ends the abnormality detection process.

[0069] At step S**408**, the abnormality detecting section **22** transmits an abnormality-confirmed message indicating that the node has been recorded as an abnormal node at step S**405** to the relevant node. Next, the abnormality detecting section **22** judges whether or not some sort of response message in response to the abnormality-confirmed message transmitted at step S**408** has been received from the node that is the transmission destination of the abnormality-confirmed message (step S**409**). When judged "YES" at step S**409**, the abnormality detecting section **22** deletes, from the non-volatile memory **14**, the transition abnormality information indicating that the relevant node is an abnormal node together with the node ID (step S**410**) and ends the abnormality detection process.

[0070] On the other hand, the abnormality detecting section **22** adds, to the relevant node ID at S**405**, information (communication abnormality information) indicating that the node

has an abnormality related to the communication function regarding the node from which a response message has not been received at step S**409**.

[0071] In other words, in the abnormality detection process, when the process is started after the elapse of the above-described sleep completion period, whether or not the sleep-entered message has been received is confirmed using the node ID included in the sleep-entered message. Nodes from which the message has been received are normal nodes. Nodes from which the message has not been received are abnormal nodes and recorded as abnormal nodes.

[Effects]

[0072] As described above, in the on-board network system **100** according to the first embodiment, depending on whether or not a message (sleep-entered message) voluntarily transmitted by each node during the bus sleep operation accompanying the state transition process has been received, when the number of sleep-entered messages received by the monitoring ECU **100**B does not reach the total number of nodes, a judgment is made that an abnormal node is present within the system.

[0073] Therefore, in the on-board network system **100**, in addition to the abnormality detection during the normal state of each node, abnormality detection can also be favorably performed during the bus sleep operation. Therefore, operation abnormality in the system can be favorably detected.

[0074] In addition, in the on-board network system **100**, the node ID is included in the sleep-entered message. The monitoring ECU **100**B manages the node IDs and uses the node IDs in the sleep-entered messages to record a node that has not transmitted the sleep-entered message as an abnormal node.

[0075] Therefore, as a result of the monitoring ECU **100**B managing the node IDs, the node within the system that has an abnormality can be identified. As a result of the identified abnormal node being recorded, repair operation of the system when an abnormality occurs can be facilitated.

[0076] In addition, in the on-board network system **100**, the monitoring ECU **100**B has the buffer **32** for temporarily storing therein management information indicating whether or not the sleep-entered message has been received. When the microcomputer **11** is turned ON, during bus wakeup when at least one of the plurality of nodes transitions from the power-saving state to the normal state, and during bus sleep cancelation when at least one of the plurality of nodes terminates the state transition process, the monitoring ECU **100**B resets the buffer **32**.

[0077] Therefore, because the buffer **32** can be reset with certainty before the bus sleep operation, whether or not the sleep-entered message has been received can be favorably confirmed using the management information during the bus sleep operation.

[0078] In the on-board network system **100**, the NM-ceased period is the period during which NM messages are not received from any of the other ECUs on the communication bus **100**A. Therefore, for example, all nodes on the communication bus **100**A can be made to perform the bus sleep operation at once.

[0079] In addition, in the on-board network system **100**, the monitoring ECU **100**B transmits the abnormality-confirmed message to the abnormal node. Depending on whether or not a response message in response to the abnormality-confirmed message has been received, the monitoring ECU **100**B updates or deletes the record of the abnormal node.

[0080] Therefore, in the on-board network system **100**, whether the sleep-entered message is not being transmitted merely because of a delay in transmission, or because of a communication abnormality can be judged. The accuracy of detection regarding communication abnormality can be enhanced.

Second Embodiment

[0081] Next, an on-board network system according to a second embodiment of the present invention will be described with reference to the FIG. **8** to FIG. **12**. According to the second embodiment, the differences with the first embodiment will mainly be described. Unless specifically described, description of each constituent element will be omitted through use of the same reference numbers as those according to the first embodiment.

[Overall Configuration]

[0082] As shown in FIG. **8**, the on-board network system **100** according to the second embodiment differs from that according to the first embodiment in that each ECU belongs to at least one of a plurality of groups divided in advance on the communication bus **100**A. In addition, a node is present that belongs to a plurality of groups.

[State Transition Process]

[0083] According to the second embodiment, in the state transition process shown in FIG. **3**, at step S**101**, the microcomputer **11** of each node periodically transmits an NM message to the communication bus **100**A. The NM message includes a subject identifier in addition to the node ID identifying the node itself. The subject identifier indicates a group ID to which the message is being transmitted, among one or a plurality of group IDs identifying the groups to which the node itself belongs. In other words, the second embodiment differs from the first embodiment in that the NM message includes information (subject identifier) identifying one or a plurality of groups that is the transmission destination.

[0084] When the node belongs to a plurality of groups, at step S**102**, the microcomputer **11** judges whether or not its own ECU can transition from the normal state to the power-saving state for each group. At step S**103**, the microcomputer **11** continues to periodically transmit NM messages to the communication bus **100**A, excluding the NM message having the subject identifier corresponding to the group judged to be unable to transition to the power-saving state at step S**102**. The second embodiment differs from the first embodiment in that the microcomputer **11** stops transmitting the NM message at step S**103** when judged at step S**102** that the transition from the normal state to the power-saving state can be made for all groups to which its own ECU belongs.

[0085] In addition, when the node belongs to a plurality of groups, at step S**104**, based on the subject identifier included in the NM message, the microcomputer **11** waits until the NM message including the subject identifier for the group is no longer being received from any of the other nodes belonging to the group, for each group. Every time the microcomputer **11** judges "YES" at step S**104**, at step S**105**, the microcomputer **11** judges whether or not the NM-ceased period exceeds the wait period. In other words, the second embodiment differs from the first embodiment in that the NM-ceased period

is a period during which the NM message including the subject identifier has not been received from any other node within the group (subject group) for each subject identifier. In addition, the second embodiment differs from the first embodiment in that the sleep condition is confirmation that the node itself is in a state in which control is not affected even should the node transitions from the power-saving state to the normal state in the subject group, and all other nodes within the subject group are able to transition to the power-saving state in the subject group.

[0086] Furthermore, the second embodiment differs from the first embodiment in that, when the node belongs to a plurality of groups, at step S**106**, the microcomputer **11**, transmits to the communication bus **100**A, a sleep-entered message including the subject identifier indicating the subject group that meets the sleep condition, in addition to the node ID identifying its own node.

[0087] For example, a configuration will be described as an example in which, in the on-board network system **100**, the keyless entry system described according to the first embodiment is one group and given the reference number PNC**1**, and a security system is another group and given the reference number PNC**2**. The on-board network system **100** in this example includes the keyless entry system PNC**1** and the security system PNC**2**. The second embodiment differs from the first embodiment in that, in the on-board network system **100**, the node **3** for locking and unlocking the vehicle door is a node belonging to a plurality of groups, or in other words, both the keyless entry system PNC**1** and the security system PNC**2**. The node **5** does not belong to the keyless entry system PNC**1**, and belongs to the security system PNC**2** and a system PNCn that is a representative of other groups.

[0088] The security system PNC**2** includes the node **3**, the node **5**, and the monitoring ECU **100**B. In the node **3**, an impact sensor S**2** is connected to its own microcomputer. The impact sensor S**2** detects impact that may damage the vehicle doors or windows. The node **5** is used to output a warning sound for security that is emitted outside of the vehicle. The monitoring ECU **100**B belongs to all systems PNC**1** to PNCn.

[0089] Specifically, in the on-board network system **100**, when the vehicle power supply is OFF, power is supplied to the impact sensor S**2** and the microcomputer **11** of the node **3**, in addition to the signal sensor S**1** and the microcomputer **11** of the node **1**. When the vehicle power supply is turned OFF in this way, if the impact sensor S**2** detects, for example, an acceleration exceeding a reference value, the microcomputer **11** returns to the normal state by performing the bus wakeup operation of its own node. The microcomputer **11** transmits a startup signal corresponding to the security system PNC**2** to the communication bus **100**A. As a result, the monitoring ECU **100**B, the node **3**, and the node **5** start the bus wakeup operation.

[0090] Then, when the bus wakeup operation is completed, the node **5** receives a control message indicating a command from the node **3**. The node **5** generates a warning sound outside of the vehicle. In addition, when the bus wakeup operation is completed, the node **3** and the node **5** periodically transmit, to the communication bus **100**A, the NM message including the subject identifier corresponding to the security system PNC**2**.

[0091] On the other hand, when the keyless entry system PNC**1** (in this instance, the node **1**) subsequently returns from the power-saving state to the normal state as a result of the signal sensor S**1** receiving a legitimate keyless signal, as described above, the node **1** periodically transmits, to the communication bus **100**A, the NM message including the subject identifier corresponding to the keyless entry system PNC**1**. Then, for example, using this as a trigger, the node **3** and the node **5** stop transmitting the NM message including the subject identifier corresponding to the security system PNC**2**.

[0092] When the node **3** and the node **5** stop transmitting the NM message including the subject identifier corresponding to the security system PNC**2** in this way, the sleep condition related to the security system PNC**2** is met. The node **3** and the node **5** transmit, to the communication bus **100**A, the sleep-entered message including the node ID corresponding to themselves and the subject identifier corresponding to the security system PNC**2**. First, only the node **5** transitions from the normal state to the power-saving state.

[0093] On the other hand, the node **3** belongs to the keyless entry system PNC**1** as well as the security system PNC**2**. Therefore, after the door is unlocked by the electronic key K**1** and the sleep condition related to the keyless entry system PNC**1** is met, as described above, the node **3** transmits, to the communication bus **100**A, the sleep-entered message including the node ID corresponding to itself and the subject identifier corresponding to the keyless entry system PNC**1**. The node **3** then transitions from the normal state to the power-saving state.

[0094] In other words, because the node **3** belongs to a plurality of groups, the node **3** transitions from the normal state to the power-saving state when the sleep condition is met for all groups to which the node itself belongs. According to the second embodiment, an example is described in which the sleep-entered message is transmitted to the communication bus **100**A every time the sleep condition is met for a group to which the node itself belongs. However, the sleep-entered message may be transmitted to the communication bus **100**A when the sleep condition is met for all groups to which the node itself belongs.

[Configuration of the Monitoring ECU]

[0095] Next, the differences with the first embodiment in the configuration of the monitoring ECU **100**B according to the second embodiment will be described.

[0096] In the monitoring ECU **100**B according to the second embodiment, as shown in FIG. **9**A, the non-volatile memory **14** stores therein a network configuration table **31**. In the network configuration table **31**, an index indicating an address within a memory of the RAM **11**B is associated with a node ID, and the group ID to which the node ID belongs is written for each node ID.

[0097] On the other hand, as shown in FIG. **9**B, the RAM **11**B is provided with the buffer **32** that serves as an area for temporarily storing management information indicating whether or not a sleep-entered message has been received for each index. The buffer **32** temporarily stores therein the management information to indicate whether or not the sleep-entered message has been received for each subject identifier.

[Buffer Update Process]

[0098] Then, in the buffer update process shown in FIG. **5**, at step S**203**, the memory managing section **23** rewrites, among the pieces of management information in the buffer **32** corresponding to the indexes extracted at step S**202**, the management information related to the subject identifier included

in the sleep-entered message received by the network managing section **21** from 0 (zero) indicating that the sleep-entered message has not been received to 1 indicating that the sleep-entered message has been received, thereby updating the buffer **32**.

[Buffer Reset Process]

[0099] Next, in the judgment regarding the timing for performing the buffer reset process shown in FIG. **6**, the memory managing section **23** judges whether or not the current timing is immediately after power supply to the microcomputer **11** (step S**301**). When judged that the current timing is immediately after power supply to the microcomputer **11** ("YES" at step S**301**), the memory managing section **23** starts the buffer restart process. Here, when the buffer reset process is started, all pieces of management information within the buffer **32** are reset to 0 (zero).

[0100] In addition, after the bus sleep state of a certain group is confirmed based on the result of the above-described buffer update process, the memory managing section **23** judges whether or not at least one node in the group has performed the bus wakeup operation based on whether or not the NM message has been received (step S**302**). When judged that a bus wakeup such as this is detected ("YES" at step S**302**), the memory managing section **23** starts the buffer reset process. Here, when the buffer rest process is started, all pieces of management information within the buffer **32** regarding only the subject identifier in the NM message by which the bus wakeup is detected at step S**302** are reset to 0 (zero).

[0101] In addition, the memory managing section **23** judges whether or not a node is present that performs an operation (bus-sleep cancel operation) to terminate the above-described state transition process by a predetermined trigger after transmitting the sleep-entered message, based on, for example, whether not a node that performs re-transmission of the NM message is present during the above-described NM-ceased period (step S**303**). When judged that a bus-sleep cancelation such as this is detected ("YES" at step S**303**), the memory managing section **23** starts the buffer reset process. Here, when the buffer rest process is started, all pieces of management information within the buffer **32** regarding only the subject identifier in the NM message by which the bus-sleep cancelation is detected at step S**303** are reset to 0 (zero).

[Abnormality Detection Process]

[0102] The abnormality detection process according to the second embodiment is started when a sleep completion period has elapsed. The sleep completion period, which is set in advance, is a period until all nodes within a group corresponding to the subject identifier included in the sleep-entered message complete the state transition process, after the network managing section **21** has received at least one sleep-entered message.

[0103] As shown in FIG. **10**, when the abnormality detection process is started, first, the abnormality detecting section **22** sets an index value (x=0) indicating the head address in the buffer **32** (step S**501**). Next, the abnormality detecting section **22** judges whether or not the index setting value x is less than the total number of nodes (step S**502**). When judged "YES" at S**502**, the abnormality detecting section **22** proceeds to step S**503**. When judged "NO" at step S**502**, the abnormality detecting section **22** proceeds to step S**507**.

[0104] At step S**503**, the abnormality detecting section **22** judges whether or not a sleep identifier is included in the subject identifiers corresponding to the index setting value x from the buffer **32**. The sleep identifier is a subject identifier indicating the group that is to transition to the power-saving state, in the sleep-entered message received by the network managing section **21**. When judged "YES" at step S**503**, the abnormality detecting section **22** proceeds to step S**504**. When judged "NO" at step S**503**, the abnormality detecting section **22** proceeds to step S**506**.

[0105] At step S**504**, the abnormality detecting section **22** extracts the management information related to the sleep identifier in step S**503** and judges whether or not the extracted management information is 1 indicating that the sleep-entered message has been received. Here, when judged "NO" at step S**504**, the abnormality detecting section **22** proceeds to step S**506**. When judged "YES" at step S**504**, the abnormality detecting section **22** proceeds to step S**505**. In other words, when judged that the management information related to the sleep identifier extracted from the buffer **32** is 0 (zero) indicating that the sleep-entered message has not been received, the abnormality detecting section **22** proceeds to step S**506**.

[0106] At step S**505**, the abnormality detecting section **22** records, in the non-volatile memory **14**, the node ID corresponding with the index setting value x in the network configuration table **31** together with information (transition abnormality information) indicating that the node is a node (abnormal node) having an abnormality related to the state transition process in the group ID corresponding to the index setting value x in the same network configuration table **31**. On the other hand, the abnormality detecting section **22** increments the index setting value x at step S**506** and returns to step S**502**.

[0107] At step S**507**, the abnormality detecting section **22** judges whether or not an abnormal node has been detected in the processing operations at step S**501** to S**506**. When judged "YES" at step S**507**, the abnormality detecting section **22** proceeds to step S**508**. When judged "NO" at step S**507**, the abnormality detecting section **22** ends the abnormality detection process.

[0108] At step S**508**, the abnormality detecting section **22** transmits an abnormality-confirmed message indicating that the node has been recorded as an abnormal node at step S**505** to the relevant node. Next, the abnormality detecting section **22** judges whether or not some sort of response message in response to the abnormality-confirmed message transmitted at step S**508** has been received from the node that is the transmission destination of the abnormality-confirmed message (step S**509**). When judged "YES" at step S**509**, the abnormality detecting section **22** ends the abnormality detection process.

[0109] On the other hand, the abnormality detecting section **22** adds, to the relevant node ID at step S**505**, information (communication abnormality information) indicating that the node has an abnormality related to the communication function regarding the node from which a response message has not been received at step S**509** (step S**510**). The abnormality detecting section **22** then ends the abnormality detection process.

[0110] In other words, in the abnormality detection process according to the second embodiment, when the process is started after the elapse of the above-described sleep comple-

tion period, whether or not the sleep-entered message related to the sleep identifier has been received is confirmed using the node ID and the subject identifier (sleep identifier) included in the sleep-entered message. Nodes from which the message has been received in the group ID corresponding with the sleep identifier are normal nodes. Nodes from which the message has not been received are abnormal nodes and recorded as abnormal nodes. In other words, the abnormality detection process is performed for each group ID.

[Effects]

[0111] As described above, in the on-board network system **100** according to the second embodiment, the subject identifier is included in the NM message and the sleep-entered message. Therefore, when the sleep condition is met regarding all groups to which a node belongs, the node can transition from the normal state to the power-saving state. The monitoring ECU **100**B can monitor the operating state of each node for each group.

[0112] In addition, in the on-board network system **100**, the monitoring ECU **100**B references the network configuration table **31** in which one or a plurality of group IDs are associated with each node ID. The monitoring ECU **100**B performs the abnormality detection process for each group ID based on the node ID and the subject identifier included in the sleep-entered message. Therefore, the abnormal node can be efficiently detected.

[0113] In addition, in the on-board network system **100**, the monitoring ECU **100**B has the buffer **32** for temporarily storing therein management information indicating whether or not the sleep-entered message has been received for each subject identifier. When the microcomputer **11** is turned ON, the monitoring ECU **100**B resets all pieces of management information in the buffer **32**. During bus wakeup when at least one of the plurality of groups transitions from the power-saving state to the normal state, and during bus sleep cancelation when at least one of the plurality of groups terminates the state transition process, the monitoring ECU **100**B resets the management information corresponding to the subject identifier of the group in the buffer **32**.

[0114] As a result, not necessarily all pieces of management information in the buffer **32** are reset at once. Therefore, the monitoring ECU **100**B can collectively perform the abnormality detection process in a state in which, for example, a certain number of pieces of management information are stored in the buffer **32**. The reception of the sleep-entered message can be efficiently checked.

Third Embodiment

[0115] Next, an on-board network system according to a third embodiment of the present invention will be described with reference to the drawings. According to the third embodiment, the differences with the second embodiment will mainly be described. Unless specifically described, description of each constituent element will be omitted through use of the same reference numbers as those according to the second embodiment.

[Configuration of the Monitoring ECU]

[0116] First, the differences with the second embodiment in the configuration of the monitoring ECU **100**B according to the third embodiment will be described.

[0117] As shown in FIG. **11**, the CPU **11**A of the monitoring ECU **100**B includes, when functionally divided, a network configuration learning section **24**, in addition to the network managing section **21**, the abnormality detecting section **22**, and the memory managing section **23**. The network managing section **21** transmits and receives the control messages to and from the communication controller **11**C. The abnormality detecting section **22** detects an abnormal operation in the nodes. The memory managing section **23** manages the RAM **11**B and the non-volatile memory **14**. The network configuration learning section **24** learns the configuration of the on-board network system **100**.

[Network Configuration Learning Process]

[0118] Here, a network configuration learning process performed by the CPU **11**A of the monitoring ECU **100**B as a function of the network configuration learning section **24** will be described with reference to the flowchart in FIG. **12**. The network configuration learning process is started at a predetermined timing before, for example, each node is assembled to the vehicle at a factory and the vehicle is shipped.

[0119] When the network configuration learning process is started, first, the network configuration learning section **24** sets the index value (x=0) indicating the head address in the network configuration table **31** stored in the RAM **11**B (step S**602**). Next, the network configuration learning section **24** judges whether or not the index setting value x is less than the maximum number of nodes that can be connected to the communication bus **100**A (step S**603**). When judged "YES" at step S**603**, the network configuration learning section **24** proceeds to step S**604**. When judged "NO" at step S**603**, the network configuration learning section **24** proceeds to step S**606**.

[0120] At step S**604**, the network configuration learning section **24** resets all elements corresponding with the index setting value x in the network configuration table **31** stored in the RAM **11**B and proceeds to step S**605**. At step S**605**, the network configuration learning section **24** increments the index setting value x and returns to step S**603**.

[0121] In this way, in the processing operations at step S**602** to S**605**, the network configuration learning section **24** resets the network configuration table **31** itself by resetting the elements related to all indexes in the network configuration table **31** stored in the RAM **11**B.

[0122] At subsequent step S**606**, the network configuration learning section **24** transmits, to the communication bus **100**A, a request message that is set in advance for learning the configuration of the on-board network system **100**. The network configuration learning section **24** then proceeds to step S**607**. Each node that has received the request message transmits a node information message to the communication bus **100**A. The node information message indicates the node ID for identifying the node itself and the group ID for identifying the group to which the node itself belongs.

[0123] In response, at step S**607**, the network configuration learning section **24** extracts the node ID and the group ID (PNCn) from the received node information message each time the node information message has been received over the communication bus **100**A. At subsequent step S**608**, the network configuration learning section **24** writes the node ID in the network configuration table **31** stored in the RAM **11**B based on the extracted results at S**607**, and updates the PNCn value corresponding to the node ID to 1.

[0124] Then, at step S**609**, the network configuration learning section **24** judges whether or not a fixed period set in advance for receiving the node information message from each node has elapsed. When judged "YES" at step S**609**, the network configuration learning section **24** proceeds to step S**610**. When judged "NO" at step S**609**, the network configuration learning section **24** returns to step S**607**. Finally, at step S**610**, the network configuration learning section **24** stores (updates), in the non-volatile memory **14**, the network configuration table **31** in which the PNCn value for all node IDs has been updated. In addition, the network configuration learning section **24** deletes the network configuration table **31** from the RAM **11**B and ends the network configuration learning process.

[Effects]

[0125] As described above, in the on-board network system **100** according to the third embodiment, the network configuration table **31** is automatically set by the network configuration learning process. Therefore, for example, even when the group to which a node belongs changes, the change can be flexibly handled. In addition, for example, when the number of nodes increases, the amount of increase is merely required to be rewritten in a program within the monitoring ECU **1008**. The network configuration table **31** is not required to be rewritten. Therefore, planning changes in the network can be made relatively easier.

Other Embodiments

[0126] The embodiments of the present invention are described above. However, the present invention is not limited to the above-described embodiments. Various embodiments are possible without departing from the scope of the present invention.

[0127] For example, in the above-described abnormality detection process according to the first and second embodiments, when an abnormal node is detected, an abnormality-confirmed message is transmitted. However, in addition to or instead of this processing operation, a command message may be transmitted to the communication bus **100**A to cancel the bus-sleep of one or a plurality of nodes within the group to which the abnormal node belongs.

[0128] In addition, according to the above-described second embodiment, the node transmits the sleep-entered message to the communication bus **100**A each time the sleep condition is met for each group to which the node belongs. However, the node may transmit the sleep-entered message to the communication bus **100**A when the sleep condition is met for all groups to which the node belongs.

[0129] In addition, in the above-described abnormality detection process according to the second embodiment, the abnormal node is detected based on the sleep identifier. However, the present invention is not limited thereto. The monitoring ECU **100**B may obtain the bus-sleep state for each group based on the NM messages and detect the abnormal node for each group based on at least the subject identifier included in the sleep-entered message.

[0130] According to the above-described first to third embodiments, the state transition process of each node in the keyless entry system PNC**1** and the security system PNC**2** is described. However, this description is merely a specific example for describing the present invention. The present invention is not necessarily limited to this specific example.

What is claimed is:

1. An on-board network system, comprising: a plurality of electronic control units that are communicably connected with each other over a communication bus, mounted in a vehicle, wherein

the plurality of electronic control units comprise nodes that performs a state transition process for transitioning from a normal state to a power-saving state, according to a sleep condition set in advance, and a master that performs an abnormality detection process for detecting an abnormality related to the state transition process for each node;

each node periodically transmits a network management (NM) message indicating that the node itself is unable to transition to the power-saving mode to the communication bus;

the sleep condition is met, when the node is able to transition to the power-saving mode, the node itself ceases transmitting the NM message, and also when NM-ceased period during which NM messages are not received from other electronic control units over the communication bus exceeds a wait period set in advance;

in the state transition process performed by each node, when the sleep condition is met, the node transmits a sleep-entered message indicating that the sleep condition is met to the communication bus; and

in the abnormality detection process performed by the master, abnormality related to the state transition process performed by each node is detected based on whether or not the sleep-entered message has been received.

2. The on-board network system according to claim **1**, wherein

the sleep-entered message includes a node ID that is capable of identifying a node from where the message is sent; and

the master manages the node IDs, wherein in the abnormality detection process, using the node ID in the sleep-entered message, the master deals with a node that sends the sleep-entered message as a normal node, and deals with a node that does not send the sleep-entered message as an abnormal node, and thereby records the ID of the abnormal node in a non-volatile memory.

3. The on-board network system according to claim **2**, wherein

the master comprises a buffer memory for temporary storing management information indicating whether or not the master received the sleep-entered message and initializes the buffer memory at the time when the master's power is switched ON, at a bus-wakeup timing in which any one of nodes' state transitions from the power-saving state to the normal state, and at a bus-sleep cancellation timing in which any one of nodes ceases the state transition process.

4. The on-board network system according to claim **3**, wherein

the NM-ceased period is a period during which none of electronic control units receives the NM message each other from other electronic control units over the communication bus.

5. The on-board network system according to claim **3**, wherein

each node belongs at least one group within a plurality of groups that are divided in advance in the communication bus;

the NM message includes a node ID that is capable of identifying a node from where the message is sent, and a subject identifier for identifying a group that the NM message is to be sent to, within one or more group IDs for identifying a group that the node belongs to;

the NM-ceased period is a period during which none of electronic control units receives a NM message including the subject identifier from all of other nodes in a group corresponding to the subject identifier;

the sleep-entered message includes the subject identifier which corresponds to a group that satisfies the sleep condition; and

in the state transition process, the normal state transfers to the power-saving mode in a case where all groups that a specific node belongs to satisfy the sleep condition.

6. The on-board network system according to claim **5**, wherein

the master refers to a network table in which each node ID corresponds to one or more group ID, thereby performs the abnormality detection process for each group ID based on both the node ID and the subject identifier that are included in the sleep-entered message.

7. The on-board network system according to claim **6**, wherein

the node sends a node information message to the communication bus when the node receives a request message set in advance, the node information message indicating both a node ID corresponding to the node and a group ID corresponding to a group that the node belongs to; and

the master sends the request message to the communication bus, and sets the network table based on the node information message received from the node.

8. The on-board network system according to claim **7**, wherein the master comprises

a buffer memory for temporary storing a management information indicating whether or not the master received the sleep-entered message for each subject identifier; and

an initializing section for initializing all management information in the buffer memory at the time when a master's power is switched ON, and for initializing a management information temporarily stored in the buffer memory, the management information corresponding to the subject identifier of said group, at a bus-wakeup timing in which at least any one of groups' state transitions from the power-saving state to the normal state and at a bus-sleep cancellation timing in which at least any one of groups ceases the state transition process.

9. The on-board network system according to claim **8**, wherein

the sleep-entered massage includes a node ID for identifying anode from which the message sent;

the master manages node IDs, wherein in the abnormality detection process, using the node ID in the sleep-entered message, the master deals with a node that sends the sleep-entered message as a normal node, and deals with a node that does not send the sleep-entered message as an abnormal node, thereby records the abnormal node in a non-volatile memory, and sends an abnormality-confirmed message to the abnormal node, thereby updates or deletes the record of the abnormal node depending on whether or not receives an answer message against the abnormality-confirmed message.

10. The on-board network system according to claim **1**, wherein

the master comprises a buffer memory for temporary storing a management information indicating whether or not the master received the sleep-entered message and initializes the buffer memory at the time when the master's power is switched ON, at a bus-wakeup timing in which any one of nodes' state transitions from the power-saving state to the normal state, and at a bus-sleep cancellation timing in which any one of nodes ceases the state transition process.

11. The on-board network system according to claim **1**, wherein

the NM-ceased period is a period during which none of electronic control units receives the NM message each other from other electronic control units over the communication bus.

12. The on-board network system according to claim **1**, wherein

each node belongs at least one group within a plurality of groups that are divided in advance in the communication bus;

the NM message includes a node ID that is capable of identifying a node from where the message is sent, and a subject identifier for identifying a group that the NM message is to be sent to, within one or more group IDs for identifying a group that the node belongs to;

the NM-ceased period is a period during which none of electronic control units receives a NM message including the subject identifier from all of other nodes in a group corresponding to the subject identifier;

the sleep-entered message includes the subject identifier which corresponds to a group that satisfies the sleep condition; and

in the state transition process, the normal state transfers to the power-saving mode in a case where all groups that a specific node belongs to satisfy the sleep condition.

13. The on-board network system according to claim **1**, wherein the sleep-entered massage includes a node ID for identifying anod e from which the message sent;

the master manages node IDs, wherein in the abnormality detection process, using the node ID in the sleep-entered message, the master deals with a node that sends the sleep-entered message as a normal node, and deals with a node that does not send the sleep-entered message as an abnormal node, thereby records the abnormal node in a non-volatile memory, and sends an abnormality-confirmed message to the abnormal node, thereby updates or deletes the record of the abnormal node depending on whether or not receives an answer message against the abnormality-confirmed message.

14. The on-board network system according to claim **2**, wherein

the NM-ceased period is a period during which none of electronic control units receives the NM message each other from other electronic control units over the communication bus.

15. The on-board network system according to claim **2**, wherein

each node belongs at least one group within a plurality of groups that are divided in advance in the communication bus;

the NM message includes a node ID that is capable of identifying a node from where the message is sent, and a subject identifier for identifying a group that the NM message is to be sent to, within one or more group IDs for identifying a group that the node belongs to;

the NM-ceased period is a period during which none of electronic control units receives a NM message including the subject identifier from all of other nodes in a group corresponding to the subject identifier;

the sleep-entered message includes the subject identifier which corresponds to a group that satisfies the sleep condition; and

in the state transition process, the normal state transfers to the power-saving mode in a case where all groups that a specific node belongs to satisfy the sleep condition.

16. The on-board network system according to claim **5**, wherein the master comprises

a buffer memory for temporary storing a management information indicating whether or not the master received the sleep-entered message for each subject identifier; and

an initializing section for initializing all management information in the buffer memory at the time when a master's power is switched ON, and initializing a management information temporarily stored in the buffer memory, the management information corresponding to the subject identifier of said group, at a bus-wakeup timing in which at least any one of groups' state transitions from the power-saving state to the normal state and at a bus-sleep cancellation timing in which at least any one of groups ceases the state transition process.

17. The on-board network system according to claim **6**, wherein the master comprises

a buffer memory for temporary storing a management information indicating whether or not the master received the sleep-entered message for each subject identifier; and

an initializing section for initializing all management information in the buffer memory at the time when a master's power is switched ON, and for initializing a management information temporarily stored in the buffer memory, the management information corresponding to the subject identifier of said group, at a bus-wakeup timing in which at least any one of groups' state transitions from the power-saving state to the normal state and at a bus-sleep cancellation timing in which at least any one of groups ceases the state transition process.

18. The on-board network system according to claim **2**, wherein

the sleep-entered massage includes a node ID for identifying anode from which the message has been sent; and

the master manages node IDs, wherein in the abnormality detection process, using the node ID in the sleep-entered message, the master deals with a node that sends the sleep-entered message as a normal node, and deals with a node that does not send the sleep-entered message as an abnormal node, thereby records the abnormal node in a non-volatile memory, and sends an abnormality-confirmed message to the abnormal node, thereby updates or deletes the record of the abnormal node depending on whether or not receives an answer message against the abnormality-confirmed message.

19. The on-board network system according to claim **3**, wherein

the sleep-entered massage includes a node ID for identifying anode from which the message has been sent; and

the master manages node IDs, wherein in the abnormality detection process, using the node ID in the sleep-entered message, the master deals with a node that sends the sleep-entered message as a normal node, and deals with a node that does not send the sleep-entered message as an abnormal node, thereby records the abnormal node in a non-volatile memory, and sends an abnormality-confirmed message to the abnormal node, thereby updates or deletes the record of the abnormal node depending on whether or not receives an answer message against the abnormality-confirmed message.

20. The on-board network system according to claim **4**, wherein

the sleep-entered massage includes a node ID for identifying anode from which the message has been sent; and

the master manages node IDs, wherein in the abnormality detection process, using the node ID in the sleep-entered message, the master deals with a node that sends the sleep-entered message as a normal node, and deals with a node that does not send the sleep-entered message as an abnormal node, thereby records the abnormal node in a non-volatile memory, and sends an abnormality-confirmed message to the abnormal node, thereby updates or deletes the record of the abnormal node depending on whether or not receives an answer message against the abnormality-confirmed message.

21. An on-board network system, comprising: a plurality of electronic control units that are communicably connected with each other over a communication bus, wherein

the plurality of electronic control units comprise nodes and a master;

any nodes comprise a section for transmitting a network management (NM) message indicating a fact that the node cannot transfer from a normal state to a power-saving state to the communication bus when a term while the node did not receive the NW message from any one of other electric units does not exceed a wait period set in advance, stopping transmitting the NW message and transmitting a sleep-entered message to the communication bus when the term while the node did not receive the NW message from any one of other electric units exceeds the wait period; and

to the master comprise a section for detecting abnormality related to said state transition process from normal state to the power-saving state performed by each node based on whether or not the sleep-entered message has been received.

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