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Disclaimer

Table of Contents

1 Introduction and overview

This protocol specification specifies the format, message sequences and semantics of the AUTOSAR Network Management (NM) protocol.

NM is intended to work together with an underlying communication stack, independent of the physical layer of the communication system used.

The AUTOSAR Network Management is a hardware independent protocol (for limitations refer to chapter 1.2.2).

The following figure shows how the NM interfaces with an upper (see 1.3.3) and a lower (bus) layer.

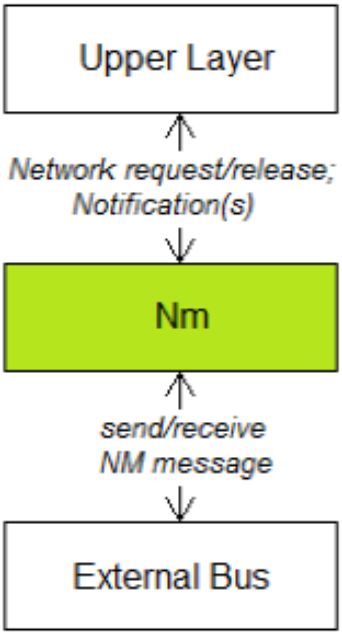

Figure 1.1: NM interfaces

1.1 Protocol purpose and objectives

Main purpose of the NM protocol is to coordinate one or more groups of ECUs to wake up and shutdown their communication stack synchronously.

The NM algorithm is based on periodic NM messages, which are received by all nodes in a NM cluster. Reception of NM messages indicates that sending nodes want to keep NM cluster awake. If any node does not need communication any more, it stops sending NM messages, but if NM messages from other nodes are received, it postpones transition to sleep mode. Finally, if a dedicated timer elapses because no NM messages are received anymore, every node initiates transition to the sleep mode, the NM node initiate the shutdown of the corresponding (partial) network.

If any node in the NM cluster requires bus-communication, it can keep the NM cluster awake by transmitting NM messages.

1.2 Applicability of the protocol

1.2.1 Constraints and assumptions

1.2.2 Limitations

1. One NM instance is associated with only one NM cluster in one network. One NM cluster can have only one instance of Nm in one node.
2. The maximum size of the NM message is limited by the used communication bus.

1.3 Dependencies

1.3.1 Dependencies to other protocol layers

NM algorithm uses services of the underlying communication stack modules to send and receive NM messages.

1.3.2 Dependencies to other standards and norms

N/A

1.3.3 Dependencies to the Application Layer

Upper layer (e.g. application) uses NM services to request or release a network i.e. to activate or deactivate sending of NM messages.

In addition, the upper layer/module may use the possibility to get informed about changes of the NM operational modes.

2 Use Cases

This chapter describes the use cases which can be realized by an environment of an ECU which implements the Network Management Protocol.

ID	*Name*	*Description*
0001	Synchronous shutdown	If there is no communication need in a NM cluster, the NM protocol ensures that all NM nodes synchronously enter sleep mode.
0002	Keep NM cluster awake	If at least one NM node in a NM cluster needs communication, the NM protocol ensures that all required NM nodes remain awake.
0003	Partial network	Support of partial network by defining communication/function domains to allow for turning off network communication across multiple ECUs in case their provided functions are not required under certain conditions. Other ECUs can continue to communicate on the same bus channels. Additionally use NM messages to communicate the request/release information of a partial network cluster between the participating ECUs.
0004	Passive mode	NM node configured as Passive node is not able to initiate a start-up of a NM cluster, however is able to be woken up if any other node initiates a start-up. This eliminates unnecessary communication and reduces bus and buffer overhead. Allowing shutdown to be controlled by a subset of the cluster's nodes enables the possibility that only fault tolerant nodes control shutdown.

3 Protocol Requirements

3.1 Requirements Traceability

Requirement	Description	Satisfied by
[RS_Nm_00047]	NM shall provide a service to request to keep the bus awake and a service to cancel this request.	[PRS_Nm_00237]
[RS_Nm_00048]	NM shall put the communication controller into sleep mode if there is no bus communication	[PRS_Nm_00103] [PRS_Nm_00115]
[RS_Nm_00054]	There shall be a deterministic time from the point where all nodes agree to go to bus sleep to the point where bus is switched off.	[PRS_Nm_00103] [PRS_Nm_00115]
[RS_Nm_00150]	Specific functions of the Network Management shall be configurable	[PRS_Nm_00013] [PRS_Nm_00045] [PRS_Nm_00074] [PRS_Nm_00075] [PRS_Nm_00158] [PRS_Nm_00328] [PRS_Nm_00405]
[RS_Nm_02505]	The NM shall optionally set the local node identifier to the NM-message	[PRS_Nm_00013] [PRS_Nm_00074]
[RS_Nm_02517]	<Bus>Nm shall support Partial Networking on CAN, FlexRay and Ethernet	[PRS_Nm_00328] [PRS_Nm_00332] [PRS_Nm_00333] [PRS_Nm_00341]
[RS_Nm_02518]	<Bus>Nm shall be able to distinguish between NM Messages	[PRS_Nm_00328] [PRS_Nm_00329] [PRS_Nm_00331] [PRS_Nm_00340]
[RS_Nm_02520]	<Bus>Nm shall evaluate the PNI bit in the NM message	[PRS_Nm_00329] [PRS_Nm_00331] [PRS_Nm_00335] [PRS_Nm_00337] [PRS_Nm_00338] [PRS_Nm_00339] [PRS_Nm_00340]
[RS_Nm_02521]	<Bus>Nm shall set the PNI bit to indicate availability of Partial Network request information	[PRS_Nm_00332] [PRS_Nm_00333] [PRS_Nm_00341]

4 Definition of terms and acronyms

4.1 Acronyms and abbreviations

Abbreviation / Acronym	Description
CAN	Controller Area Network
CBV	Control Bit Vector
FR	FlexRay
MTU	Maximum Transmission Unit
NM	Network Management
PN	Partial Network
PNC	Partial Network Cluster
PNI	Partial Network Information
UDP	User Datagram Protocol
UDPNM	UDP Network Management

4.2 Definition of terms

Term	Description
Bus-Sleep Mode	In this state no NM message is sent
FlexRay communication cycle	Part of FlexRay communication schedule consisting of time slots (static or dynamic). Each FlexRay message is assigned to a specific time slot in one communication cycle.
NM cluster	Set of NM nodes coordinated with the use of the NM algorithm.
NM Message	Refers to the payload transmitted on the bus. It contains the User Data as well as the Control Bit Vector and may contain the Source Node Identifier.
Normal Operation	In this state the node is sending periodic NM messages in order to keep a NM cluster awake
Repeat Message State	This state ensures that transition, through a repetitive transmission of NM messages, to normal operation is visible for other nodes on the bus
Repeat Message Request	Request (received internally or externally via an NM message) to transition back to the Repeat Message State
NM Node	A ECU (electornic controll unit) which is connected to one or more NM clusters
NM instance	A NM instance represents the current status of one NM cluster inside one NM node
External Request	Communication request via received NM message
Internal Request	Communication request via a NM node internal (request by application / uppler layer)
Passive wakeup	A wakeup triggered by an external request
Active wakeup	A wakeup triggered by an internal request

5 Protocol specification

5.1 NM message format

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	Control Bit Vector (default)							
Byte 1	Source Node Identifier (default)							
Byte 2	User data 0							
Byte 3	User data 1							
Byte 4	User data 2							
Byte 5	User data 3							
...	...							
Byte n	User data n-2							

Table 5.1: NM message layout

[PRS_Nm_00076] ⌈ The length of a NM message shall not exceed the MTU of the underlying physical transport layer. ⌋*()*

[PRS_Nm_00077] ⌈ The length (in bytes) of the user data in a NM message shall be configured by [UserDataLength]. ⌋*()*

5.1.1 Source Node Identifier

[PRS_Nm_00074] ⌈ The location of the source node identifier shall be configurable to position Byte 0 or Byte 1 or Off (default: Byte 1). ⌋*(RS_Nm_00150, RS_Nm_02505)*

[PRS_Nm_00013] ⌈ The source node identifier shall be available (set to a configurable value) unless the location of the source node identifier is set to Off. ⌋*(RS_Nm_00150, RS_Nm_02505)*

5.1.2 Control Bit Vector

[PRS_Nm_00075] ⌈ The location of the Control Bit Vector shall be configurable to position Byte 0 or Byte 1 or Off (default: Byte 0). ⌋*(RS_Nm_00150)*

[PRS_Nm_00045] ⌈ The Control Bit Vector shall consist of:

- Bit 0: Repeat Message Request

  0: Repeat Message State not requested

  1: Repeat Message State requested
- Bit 3: NM Coordinator Sleep Ready Bit

0: Start of synchronized shutdown is not requested by main coordinator

1: Start of synchronized shutdown is requested by main coordinator

- Bit 4: Active Wakeup Bit

  0: Node has not woken up the network (passive wakeup)

  1: Node has woken up the network (active wakeup)

- Bit 6: Partial Network Information Bit (PNI)

  0: NM message contains no Partial Network request information

  1: NM message contains Partial Network request information

- Bits 1,2,5,7 are reserved for future extensions

  0: Disabled/Reserved for future usage

⌋(*RS_Nm_00150*)

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0/1	Reserved	PNI	Reserved	Active Wakeup	NM Coordinator Sleep Ready	Reserved	Reserved	Repeat Message Request

Table 5.2: CBV layout

Note: For FlexRay bit 7 is used as the Vote bit in certain schedule variants.

5.1.3 User Data

User Data is considered all data not being part of CBV and NID.

[PRS_Nm_00158] ⌈ It shall be possible to enable or disable the support of NM user data (NM user data is optional). ⌋(*RS_Nm_00150*)

5.2 Partial Networking

[PRS_Nm_00405] ⌈ It shall be possible to enable or disable the PN support (PN feature is optional). ⌋(*RS_Nm_00150*)

[PRS_Nm_00335] ⌈ Nodes participating in the communication of partial networking shall be pre-configured with the offset and range (in bytes) of the Partial Network Information within the NM message. ⌋(*RS_Nm_02520*)

Note: every bit of the PN Info Range represents one Partial Network. If the bit is set to 1 the Partial Network is requested. If the bit is set to 0 there is no request for this PN.

[PRS_Nm_00337] ⌈ If configured to do so the NM algorithm shall only process messages containing PN request information if they contain at least one bit set to 1 that corresponds to a PNC which is relevant for the ECU. ⌋*(RS_Nm_02520)*

Note: Relevance means all PNC where the ECU is interested in (e.g. configured PNCs).

[PRS_Nm_00338] ⌈ If a message containing a PNC bit set to 1 is received, that PNC shall be considered "externally requested". ⌋*(RS_Nm_02520)*

[PRS_Nm_00339] ⌈ If one or more applications are requesting a PNC this PNC shall be considered "internally requested". ⌋*(RS_Nm_02520)*

5.2.1 Handling of Rx NM messages

[PRS_Nm_00328] ⌈ If PN support is disabled on a specific node, then its NM shall ignore any partial networking information contained in the received message. ⌋*(RS_Nm_00150, RS_Nm_02517, RS_Nm_02518)*

[PRS_Nm_00329] ⌈ If the PN support is enabled on a specific node and the PNI bit in the received NM message is 0, the node's NM shall ignore the partial networking information bytes of the message. ⌋*(RS_Nm_02518, RS_Nm_02520)*

[PRS_Nm_00331] ⌈ If the PN support is enabled and the PNI bit in the received NM message is 1, NM shall process the Partial Networking Information of the NM message. ⌋*(RS_Nm_02518, RS_Nm_02520)*

[PRS_Nm_00340] ⌈ If one PNC is not requested again (relevant PNC bit is not set to 1 again) within [PnResetTime] this PN shall be considered as "not requested". ⌋*(RS_Nm_02518, RS_Nm_02520)*

5.2.2 Handling of Tx NM messages

[PRS_Nm_00332] ⌈ If the PN support is enabled in a node, its NM shall set the value of the transmitted PNI bit in the CBV to 1. ⌋*(RS_Nm_02517, RS_Nm_02521)*

[PRS_Nm_00333] ⌈ If the PN support is disabled in a node, its NM shall set the value of the transmitted PNI bit in the CBV to 0. ⌋*(RS_Nm_02517, RS_Nm_02521)*

[PRS_Nm_00341] ⌈ For PNCs that are "internally requested" the corresponding bit in the PN request information shall be set to 1 before sending the NM message. ⌋ *(RS_Nm_02517, RS_Nm_02521)*

Constraint: The usage of the CBV is mandatory in case Partial Networking is used. This must be ensured by configuration in the respective platform.

5.3 Timing behavior

5.3.1 Sending NM message

If communication on the bus is needed i.e. requested, NM messages are sent out. If no communication is needed i.e. released, sending of NM messages is stopped.

[PRS_Nm_00237] ⌈ NM messages shall be sent periodically in states "Repeat Message" and "Normal Operation" using configured NM Message Cycle Time (NmMsgCycleTime). ⌋*(RS_Nm_00047)*

[PRS_Nm_00334] ⌈ When the "Repeat Message" state is entered because of network request or repeat message request and configured number of immediate NM transmissions is greater than zero (see NmImmediateNmTransmissions), these immediate NM messages shall be transmitted using Immediate NM Cycle Time (see NmImmediateNmCycleTime). ⌋*()*

[PRS_Nm_00102] ⌈ The NM messages shall be sent in the "Repeat Message" state for a configurable amount of time determined by the NM Repeat Message Time (see NmRepeatMessageTime). After this time has expired, the "Repeat Message" state shall be left. ⌋*()*

5.3.2 Transition to Bus-Sleep Mode

When a NM node does not need the communication on a bus, it will not immediately shut down i.e. switch to Bus-Sleep Mode. Instead, it will first change to the so called Ready Sleep state. This state ensures that any NM node in the NM cluster waits to transition to the Bus-Sleep Mode as long as any other node keeps the NM cluster awake.

[PRS_Nm_00103] ⌈ If bus communication is released, the NM algorithm shall perform transition to the Bus-Sleep Mode after a configurable amount of Ready Sleep Time has expired and no new communication request occurs in between and no NM Message has been received. ⌋*(RS_Nm_00048, RS_Nm_00054)*

Note: The Ready Sleep Time depends on the used network, refer to 5.4.

5.4 Networks specifics

5.4.1 CAN and Ethernet

On the transition path from Network to Bus-Sleep Mode, CAN NM and UDP NM introduce Prepare Bus Sleep Mode. The purpose of this state is to ensure that all nodes have time to stop their network activity before the Bus Sleep state is entered.

[PRS_Nm_00115] ⌈ The NM shall stay in the Prepare Bus-Sleep Mode for an amount of time determined by the Wait Bus-Sleep Time. After this time has expired, the Prepare Bus-Sleep Mode shall be left, and the Bus-Sleep Mode shall be entered. ⌋ *(RS_Nm_00048, RS_Nm_00054)*

Note: Thus the Ready Sleep Time is extended by Wait Bus-Sleep Time (NmWaitBus-SleepTime). The Ready Sleep Time on CAN and Ethernet starts when bus communication is released and it ends NM Timeout Time (NmTimeoutTime) after last NM messages was transmitted or received on the bus.

5.4.2 FlexRay

In addition to NM message containing data (see Figure 5.1), the FlexRay NM specifies so-called NM-Vote messages.

In fact, the FlexRay NM algorithm is based on periodic NM-Vote messages received by all nodes in the cluster. Reception of a NM-Vote message indicates that the sending node wants to keep the NM cluster awake.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	Vote	Set to "0"						

Table 5.3: NM-Vote message layout

[PRS_Nm_00116] ⌈ The NM-Vote message format shall contain a Voting Bit (Vote) with the following meaning:

0 - vote against keeping awake

1 - vote for keeping awake

⌋ *()*

[PRS_Nm_00117] ⌈ The FlexRay NM shall be able to separately transmit NM-Data and NM-Vote, or to combine them within one NM message (in either static or dynamic

slot). Transmission format shall be configurable (Schedule Variant). ⌋()

When the NM-Vote and NM-Data are combined (by Bit OR-ing) within one NM message, the content of the NM-Vote will be combined with the content of the Control Bit Vector Byte.

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 0	Vote	PNI	Reserved	Active Wakeup	NM Coordinator Sleep Ready	Reserved	Reserved	Repeat Message Request

Table 5.4: Combined NM-Vote and CBV

Each ECU, which participates in the FlexRay NM, is synchronized to a global time based on periodic repetition of the FlexRay communication cycle. To assure synchronous behaviour of all ECUs in a NM cluster, the FlexRay NM aligns the state changes to a NM Repetition Cycle, which is aligned to a FlexRay communication cycle.

Every transition is bound to repetition cycles (refer to configuration parameter NmRepetitionCycle). Therefore the Ready Sleep Time is defined as the time that starts when a new repetition cycle starts after bus communication has been released and ends NmReadySleepCnt+1 repetition cycles without any NM-Vote.

[PRS_Nm_00118] ⌈ The FlexRay NM shall specify the following cycle configuration parameters:

Voting Cycle - number of cycles needed to transmit NM-Vote of every node at least once

Data Cycle - number of cycles needed to transmit the NM-Data of every node at least once

Repetition Cycle - number of repetitions of Voting Cycle

⌋()

5.5 Sequences

5.5.1 Communication request

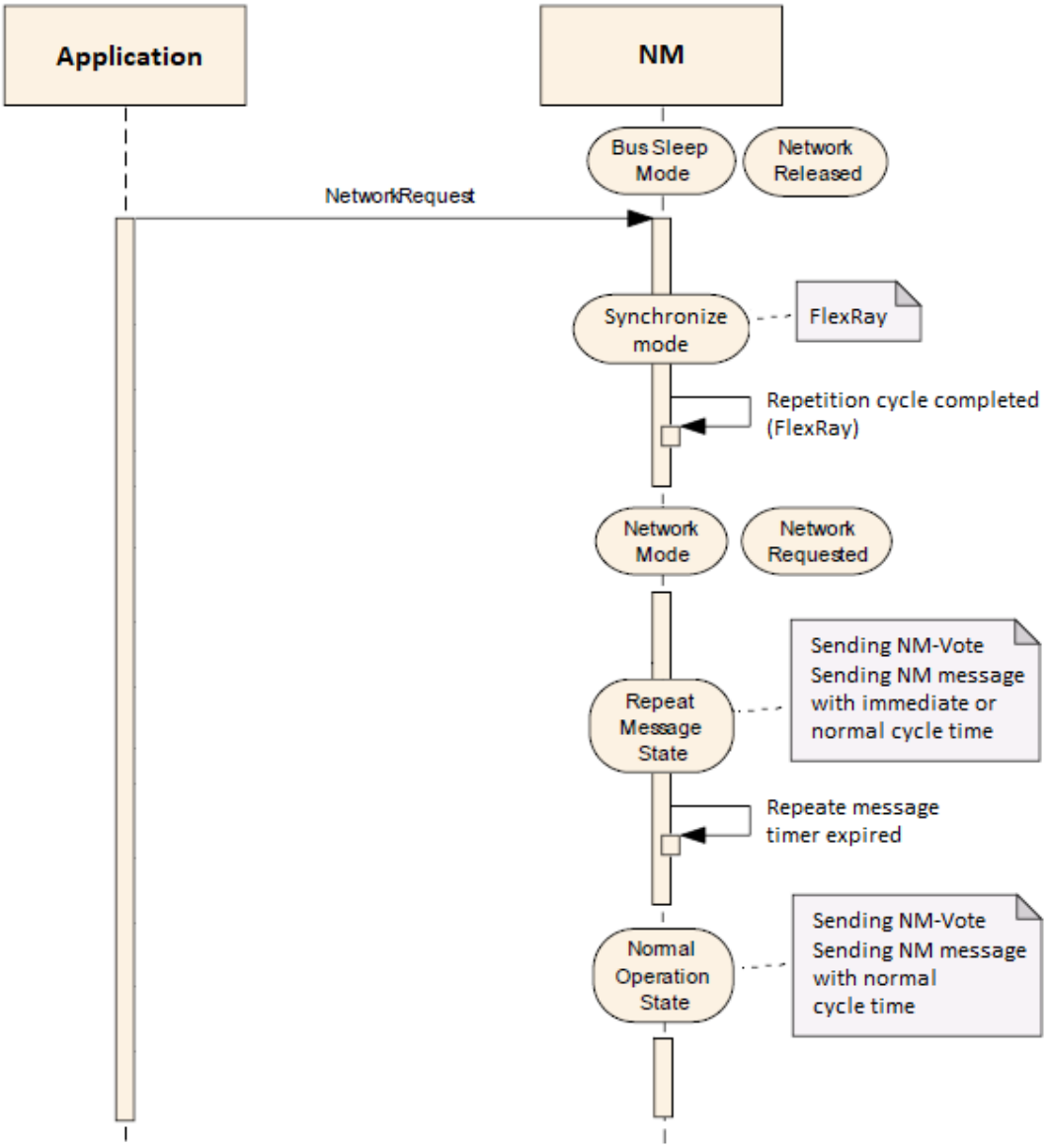

Figure 5.1: Communication request

5.5.2 Communication release

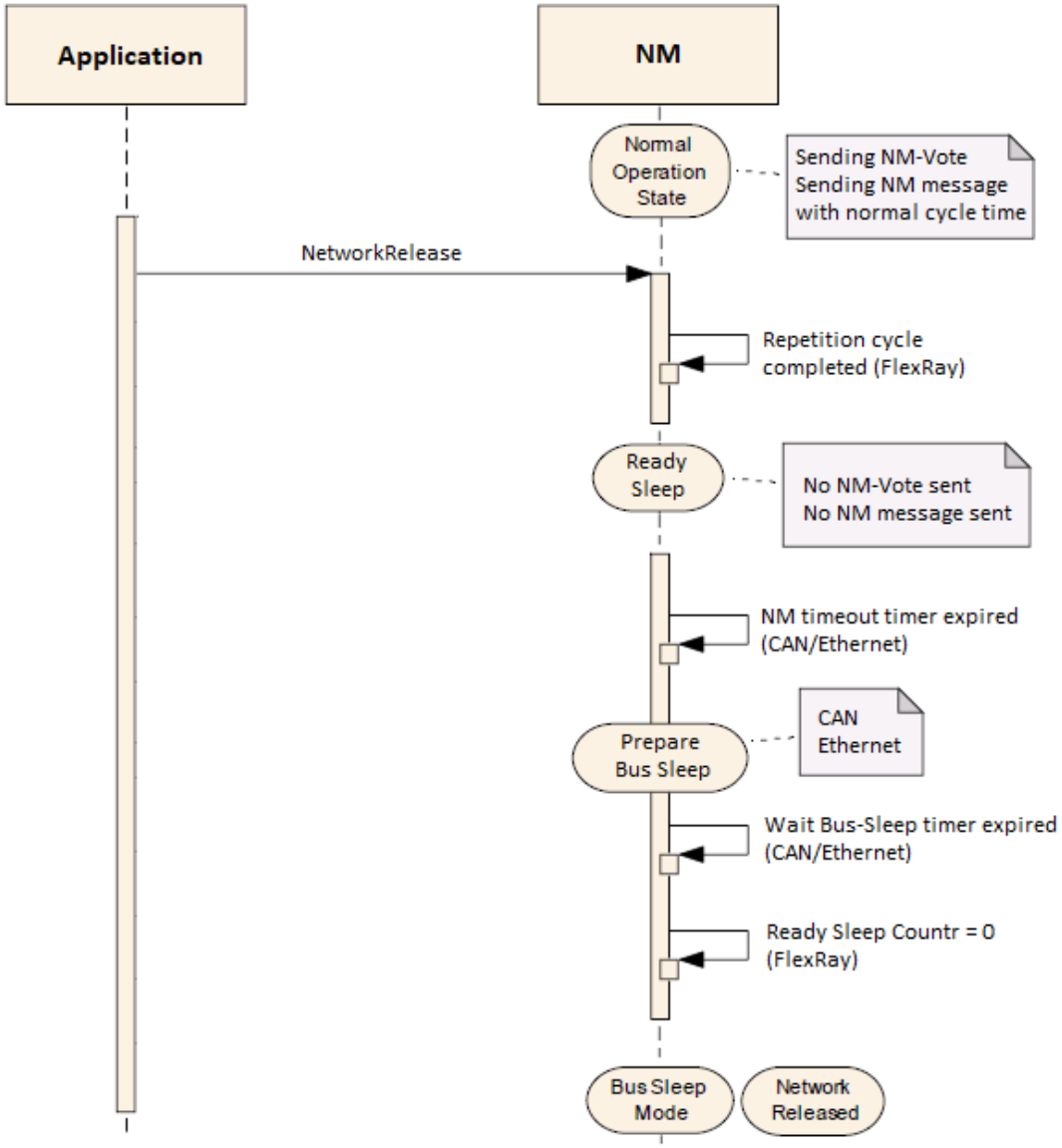

Figure 5.2: Communication release

6 Configuration parameters

This chapter lists all parameters the NM protocol uses.

6.1 NM Message Layout

Parameter	Description
NmNidPosition	Defines the position of the source node identifier (if used) within the NM message
NodeId	Node identifier of local node
NmCbvPosition	Defines the position of the Control Bit Vector (if used) within the NM message
UserDataEnabled	Enables/disables user data support
UserDataLength	Specifies the length (in bytes) of the user data information in the NM message
PnEnabled	Enables/disables support of partial networking
PnInfoOffset	Offset of the PN request information in the NM message
PnInfoLength	Length of the PN request information in the NM message

6.2 Timeout Parameters

Parameter	Description
NmTimeOutTime	The time for a node between the reception of the last NM message keeping it awake to the transition to Bus Sleep
NmMsgCycleTime	The transmission periodicity of an NM message by a node
NmRepeatMessageTime	The time for a node to remain in Repeat Message State
NmWaitBusSleepTime	Timeout for bus calm down phase. It denotes the time in seconds how long the NM shall stay in the Prepare Bus-Sleep Mode before transition into Bus-Sleep Mode (CAN NM, UDP NM only).
NmReadySleepCnt	Ready sleep counter. After NmReadySleepCnt+1 repetition cycles without any NM-Vote, NM enters Bus-Sleep (FR NM only).
NmImmediateNmCycleTime	Defines the immediate NM message cycle time in seconds used in Repeat Message state (CAN NM, UDP NM only)
NmImmediateNmTransmissions	Number of immediate NM messages which shall be transmitted in Repeat Message state (CAN NM, UDP NM only)
NmDataCycle	Number of FlexRay Schedule Cycles needed to transmit NM-Data of all ECUs (FR NM only)
NmVotingCycle	Number of FlexRay Schedule Cycles needed to transmit NM-Vote of all ECUs (FR NM only)
NmRepetitionCycle	Number of NM voting cycles where no change of voting behavior is possible (FR NM only)
NmScheduleVariant	Defines the transmission scheduling variant for sending NM-Vote and NM-Data
PnResetTime	Time a PNC is considered reqested externally after the last message containing the corresponding bit set to one has been received

7 Protocol usage and guidelines

No additional guidelines or How-To instructions for implementer.
All relevant information already provided in previous chapters.