CAN&CANFD Network Management Requirement

CAN&CANFD 网络管理规范要求

SOR-Appendix T10

Revision history/修改历史

Date Y/M/D 年/月/日	Edition Change 版本更改	Paragraph Number 段落编号	Change Content 变更内容	Reviser 修订人
2021/10/30	V1.0		初始版本	焦根生
2021/11/26	V1.1	3.0 章节	删除5.1对AUTOSAR版本的引用；	焦根生
		3.0 章节	描述“本地网络请求” -> “本地唤醒事件”	焦根生
		3.3 章节	增加User data 0中位0的定义	焦根生
		3.3 章节	增加ECU需要接收的NM报文CAN ID范围	焦根生
		3.7 章节	NM时间参数和ECU启动时间参数增加tolerance限制	焦根生
		3.4.1 章节	准备总线休眠模式下支持接收APP报文	焦根生
		3.5 章节	增加发送所有周期性报文至少一次的时间要求。	焦根生 曹晓政
2021/02/22	V2.0	3.2.3 章节	更改 3.2.3 章节 ECU 从 NOS 或 RSS 进入 RMS 模式后，不再进行快发;	焦根生
		3.3 章节	更改 3.3 网络管理帧格式章节 CBV 位 Bit4 的描述,增加 CANFD NM 报文格式的描述；	曹晓政
		3.4 章节	删除 3.4 章节关于快发部分 10ms 以内的描述，快发报文周期参考表 4 网络管理定时参数值	焦根生
		3.5 章节	变更 3.5 章节为 3.7 章节，修改 3.7 ECU 启动部分 T_networkStart 的英文描述	曹晓政
		3.5 章节	添加 3.5 章节 ECU 对于错误机制的处理；	焦根生
		3.6 章节	添加 3.6 章节 ECU 对于诊断报文的处理机制	曹晓政
2022/07/06	V2.1	3.2 章节	1. 图 2 针对从 Prepare Bus Sleep Mode 进入 Repeat Message State 增加 Action 说明	焦根生
		3.4.1 章节	1. 表 4 参数 CanNmImmediateNmCycleTime 改为 0.02s 2. 明确通过 UDS $28 服务使能或禁止 NM 报文的发送 3. 增加网络管理任务处理周期说明和要求	焦根生
		3.6 章节	1. Normal message state 修正为 Normal Operation State 2. 区分不同诊断请求维持网络请求的时间 3. 增加说明：ECU 处于准备总线休眠模式下收到诊断请求后，不应发出诊断应答	曹晓政
2022/11/07	V2.2	3.2.3 章节	增加说明： NM-Timeout 定时器的时间由参数 CanNmTimeoutTime 确定	焦根生
		3.4.1 章节	1. 表 4 参数 CanNmImmediateNmTransmissions 修改为 40 2. 表 4 参数 CanNmRepeatMessageTime Tolerance 修改为±10% 3. 表 4 参数 CanNmMsgCycleTime 修改为 0.5s	焦根生
		3.4.2 章节	表 5 Bus-Sleep Mode 下 ECU 是否对 APP 报文做 Acknowledge 不做限制	邢磊
		3.5 章节	针对网关节点，增加长时间 NotAcknowledge 处理要求	焦根生
		3.6 章节	如果此诊断请求使得 ECU 当前诊断会话保持默认会话，则维持时间持续到 ECU 发出诊断应答为止。 修改为： 如果此诊断请求使得 ECU 当前诊断会话保持默认会话，则维持时间持续到诊断请求处理结束为止。	焦根生

目录

1 简介

1.1 文档简述

本标准规定了小米汽车 CAN 和 CAN FD 总线上 ECU 遵循的通用网络管理需求。

1.2 适用范围

本标准规定了小米汽车 CAN 和 CAN FD 总线上 ECU 遵循的通用网络管理需求。任何和本技术标准不一致的偏差需要获得小米汽车网络工程师的同意。

This standard specifies generic CAN Network Management requirements for the CAN-interfaced ECU which is connected on CAN/CANFD network on Xiaomi vehicle program. Any deviations from any part of this technical standard must be agreed with the responsible Xiaomi network engineer.

1.3 规范性引用文件

下列引用文档对于本文档的应用是必不可少的。标注日期的引用文件，仅标注日期的版本适用。未标注日期的引用文件，其最新版本（包括所有的修正项）适用于本标准。

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

标号	标题	版本/修改日期
Ref.1	ISO 11898-1-2015: Data link layer and physical signaling, 2015	
Ref.2	ISO 11898-2-2016: High-speed medium access unit, 2016	
Ref.3	SAE J2284-4-2016 High Speed CAN (HSC) for Vehicle Applications at 500kbps with CAN FD Data at 2Mbps	
Ref.4	AUTOSAR_SWS_CANNetworkManagement, V4.3.1	
Ref.5	ISO/IEC 7498-1	
Ref.6	ISO/IEC 10731	

1.4 术语及缩写的解释

控制器局域网 Controller Area Network(CAN)

用于车载控制器之间传输信号的现场总线

灵活数据速率控制器局域网 CAN Flexible Data rate(CAN FD)

基于 CAN 标准，数据速率可灵活调整的通信协议

数据长度代码 Data Length Code(DLC)

CAN 总线上传输数据帧数据负载的长度

电子控制单元 Electronic Control Unit(ECU)

由集成电路组成的用于实现对数据分析处理发送等一系列功能的控制装置

CAN 网络管理模块 CAN Network Management(CanNm)

一种协调 CAN 网络中多个 ECU 休眠和唤醒的软件模块

汽车开放系统架构 Automotive Open System Architecture(AUTOSAR)

一种车载 ECU 软件架构

协议数据单元 Protocol Data Unit(PDU)

OSI 模型中每层接收来自上层信息和当前层附加信息的整体

统一建模语言 Unified Modeling Language(UML)

为面向对象系统设计的建模工具

部分网络信息 Partial Network Information(PNI)

网络管理报文控制位向量中的 bit6

统一诊断服务 Unified Diagnostic Service(UDS)

诊断服务的规范化标准

CAN 总线数据库 DataBase CAN(DBC)

描述 CAN 网络上报文信息，节点和总线信息的数据库

开发系统互联 Open System Interconnection (OSI)

试图使各种计算机在世界范围内互联为网络的标准框架

2 基于 CAN 通信层模型 CAN Layer Model

CAN通讯基于分层模型，由物理层、数据链路层、交互层和网络管理组成。参考图1描述的通信层次关系。本文档描述了网络管理部分需求。

The Communication is based on a layer model and consists of physical layer, data link layzer, interaction layer and network management layer. This illumination describes the hierarchy of a communication kernel, please refer to figure 1. This document describs the requirement of Network Management Layer.

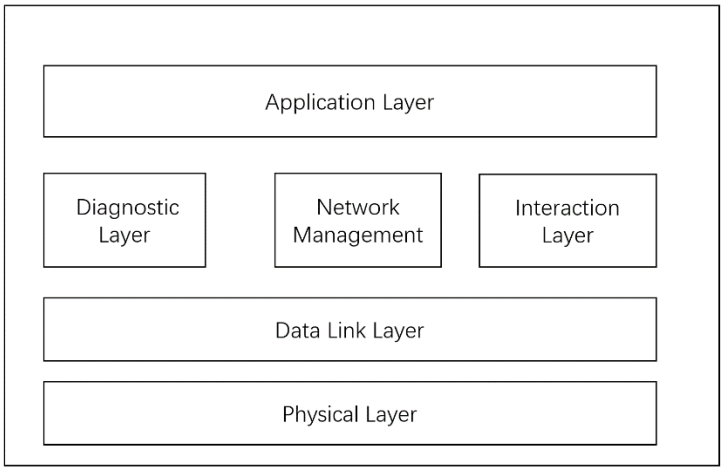

图1 协议层次和结构 Figure 1 Protocol layered structure

3 网络管理需求 Network Management Requirement

3.1 CAN 网络管理概述和状态机 CAN Network Management overview and state machine

本小节描述了基于 AUTOSAR_SWS_CANNetworkManagement 的 CAN 节点网络管理需求.

This subclause describes the Network Management requirements for CAN nodes which is specified based on AUTOSAR_SWS_CANNetworkManagement.

小米汽车上的 CAN 节点基于多主的直接网络管理策略，该策略中每个网络节点都需要基于在网络中接收或发送的网络管理报文实现相应的网络行为。

CAN nodes in Xiaomi Vehicle shall use decentralized direct network management which means that every network node performs activities self-sufficient depending on the NM PDUs only that are received or transmitted within the communication system.

CAN 网络管理机制通过发送周期性的网络管理报文实现，该网络管理报文通过广播方式被总线上所有节点接收。节点通过发送网络管理报文，表示自身需要网络保持唤醒状态。

The Xiaomi Can Network Management algorithm is based on periodic Network Management PDUs, which are received by all nodes in the cluster via broadcast transmission. Reception of Network Management PDUs indicates that sending nodes want to keep the network management cluster awake.

如果某个节点准备好进入总线休眠模式，其应该停止发送网络管理报文，如果状态转换期间收到其他节点发的网络管理报文，应推迟进入总线休眠模式。最终如果在一段特定时间内收不到任何网络管理报文，那么所有节点都将进入总线休眠模式。

If any node is ready to go to the Bus-Sleep Mode, it stops sending Network Management PDUs, but as long as Network Management PDUs from other nodes are received, it postpones transition to the Bus-Sleep Mode. Finally, if a dedicated timer elapses because no Network Management PDUs are received anymore, every node initiates transition to the Bus-Sleep Mode.

CAN 网络管理整体功能通过状态机描述，这个状态机从网络中某个节点的视角描述了状态、状态切换和触发条件等。

The overall functions of Can Network Management algorithms can be define as CanNm state machine and this state machine shall contain states, transitions and triggers seen from point of view of one single node in the network management cluster.

3.2 CAN 网络管理状态机 CAN Network Management state machine

图2从单个节点的视角描述了CAN网络管理状态机，网络模式和睡眠模式状态机的跳转参照 AUTOSAR_SWS_CANNetworkManagement V4.3.1。

An UML state chart of CanNm state machine from point of view of one single node in the network management cluster can be found in detail as figure 2. The switching between network mode and sleep mode state machine refers to AUTOSAR_ SWS_ CANNetworkManagement V4.3.1

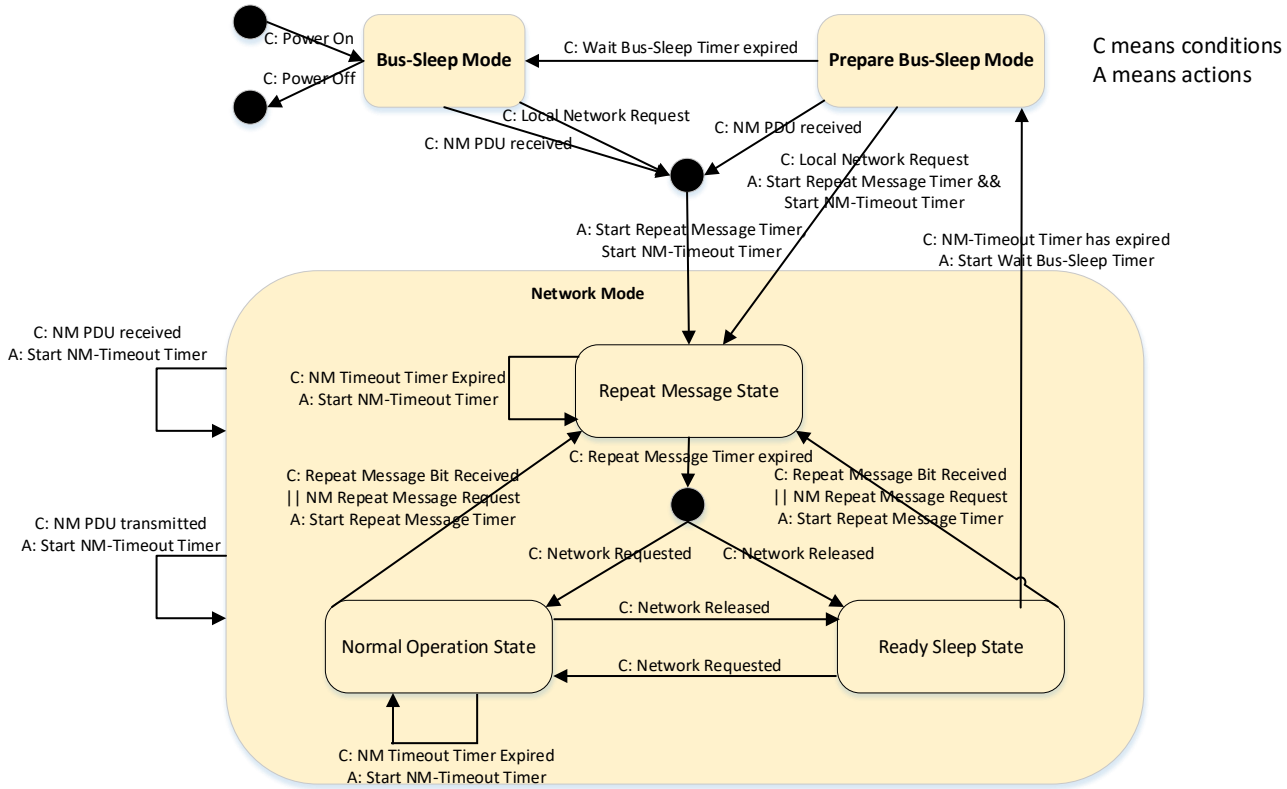

图2 CAN网络管理运行模式 Figure 2 CanNm Operation Mode

3.2.1 总线休眠模式 Bus-Sleep Mode

总线休眠模式的目的是当总线上没有通信需求时从而减少对电池电量的消耗。当节点CAN控制器进入总线休眠模式后，对电池电量消耗会降低到合适的水平并进入到低功耗模式，此时节点应使能唤醒机制。在ECU上电后，在收到本地唤醒事件或其他节点网络管理报文之前，应处于总线休眠模式。

The purpose of the Bus-Sleep Mode is to reduce power consumption in the node when no messages are to be exchanged. The communication controller is switched into the sleep mode, respective wakeup mechanisms are activated and finally power consumption is reduced to the adequate level in the Bus-Sleep Mode. After power on, the ECU shall stay in Bus Sleep Mode before ECU has local network requests or receives NM PDU successfully

当CAN网络管理模块处于总线休眠模式时，如果收到一个有效的网络管理报文或本地有网络请求，那么CAN网络管理模块应该从总线休眠模式默认进入重复报文状态。

When the CanNm module successfully receives a Network Management PDU or the network is requested locally in the Bus-Sleep Mode, the CanNm module shall leave Bus Sleep Mode and enter Repeat Message State by default.

3.2.2 准备总线休眠模式 Prepare Bus-Sleep Mode

准备总线休眠模式的目的是保证所有节点在进入总线休眠模式前有时间停止其网络活动。在准备总线休眠模式，总线活动减少（也就是发送队列中的报文被发送以清空发送缓存），最终总线上将不再有任何活动。

The purpose of the Prepare Bus Sleep Mode is to ensure that all nodes have time to stop their network activity before the Bus-Sleep Mode is entered. In Prepare Bus-Sleep Mode the bus activity is calmed down (i.e. queued messages are transmitted in order to make all Tx-buffers empty) and finally there is no activity on the bus in the Prepare Bus-Sleep Mode.

CAN网络管理模块应在准备总线休眠模式下停留一段时间（CanNmWaitBusSleepTime），该参数可通过配置修改。该时间过后，CAN网络管理模块应从准备总线休眠模式进入总线休眠模式。

The CanNm module shall stay in the Prepare Bus-Sleep Mode for a configurable amount of time determined by the CanNmWaitBusSleepTime (configuration parameter); after that time the Prepare Bus-Sleep Mode shall be left and the Bus-Sleep Mode shall be entered.

在准备总线休眠模式下，如果收到有效的网络管理报文，CAN网络管理模块应该从准备总线休眠模式进入重复报文状态。

At successful reception of a Network Management PDU in the Prepare Bus-Sleep Mode, the CanNm Module shall leave the Prepare Bus Sleep Mode and enter the CanNm Module shall enter the Repeat Message State.

在准备总线休眠模式下，如果本地有网络通信请求，CAN 网络管理模块应进入网络模式，默认进入网络模式下的重复报文状态。

When the network is requested in the Prepare Bus-Sleep Mode, the CanNm module shall enter the Network Mode; by default the CanNm Module shall enter the Repeat Message State.

3.2.3 网络模式 Network Mode

网络模式包括3种内部状态：

The Network Mode shall consist of three internal states:

- Repeat Message State 重复报文状态
- Normal Operation State 正常运行状态
- Ready Sleep State 休眠就绪状态

当节点从总线休眠模式或准备总线休眠模式进入网络模式，CAN网络管理模块应开启NM-Timeout定时器。

When the Network Mode is entered from Bus Sleep Mode or Prepare Bus Sleep Mode, the CanNm module shall start the NM-Timeout Timer.

当节点处于网络模式并且收到有效的网络管理报文，CAN网络管理模块应重启NM-Timeout定时器。

At successful reception of a Network Management PDU in the Network Mode, the CanNm module shall restart the NM-Timeout Timer.

当节点处理网络模式并且成功发出网络管理报文，CAN网络管理模块应重启NM-Timeout定时器。

At successful transmission of a Network Management PDU in the Network Mode, the CanNm module shall restart the NM-Timeout Timer.

NM-Timeout定时器的时间见表4参数CanNmTimeoutTime。

The configuration parameter CanNmTimeoutTime shall determine the AUTOSAR CanNm timing parameter NM-Timeout Time.

3.2.3.1 重复报文状态 Repeat Message State

重复报文状态确保网络上其他节点能观察到该节点从总线休眠模式或准备总线休眠模式进入网络模式的状态变化。另外该状态使节点至少保持一段最小时间的活动状态，可以被用来检测在线节点。

The Repeat Message State ensures that any transition from Bus-Sleep or Prepare Bus-Sleep to the Network Mode becomes visible to the other nodes on the network. Additionally it ensures that any node stays active for a minimum amount of time. It can be used for detection of present nodes.

当节点从其他模式或状态进入重复报文状态后,CAN网络管理模块应开始(重新开始)发送网络管理报文。

When the Repeat Message State is entered from any other Modes or states the CanNm module shall (re-)start transmission of Network Management PDUs.

当节点处于重复报文状态，且NM-Timeout定时器超时，CAN网络管理模块应开始（重新开始）NM-Timeout定时器。

When the NM-Timeout Timer expires in the Repeat Message State, the CanNm module shall (re-)start the NM-Timeout Timer.

网络管理状态机应在重复报文状态下保持一段时间（CanNmRepeatMessageTime），之后CAN网络管理模块应离开重复报文状态。

The network management state machine shall stay in the Repeat Message State for a configurable amount of time determined by the CanNmRepeatMessageTime, after that time the CanNm module shall leave the Repeat Message State.

在节点离开重复报文状态后，如果节点对网络通信有需求，CAN网络管理模块应进入正常运行状态。

When Repeat Message State is left and if the network has been requested, the CanNm module shall enter the Normal Operation State.

在节点离开重复报文状态后，如果节点对网络通信没有需求，CAN网络管理模块应进入休眠就绪状态。

When Repeat Message State is left and if the network has been released, the CanNm module shall enter the Ready Sleep State.

CAN网络管理模块在离开重复报文状态后应复位网络管理报文中的重复报文标志位。

CanNm shall clear the Repeat Message Bit when leaving the Repeat Message State.

节点在重复报文状态、准备总线休眠模式或总线休眠模式时，如果其他模块（比如ComM）调用重复报文请求，CAN网络管理模块不能执行该请求。

If the other module (e.g. ComM) calls CanNm for Repeat Message Request in Repeat Message State, Prepare Bus-Sleep Mode or Bus-Sleep Mode, the CanNm module shall not execute the request.

3.2.3.2 正常运行状态 Normal Operation State

正常运行状态确保只要节点对网络通信有需求，就可以让整个网络处于唤醒状态。

The Normal Operation State ensures that any node can keep the network management cluster awake as long as the network is requested.

如果节点从休眠就绪状态跳转到正常运行状态，应立刻开始发送网络管理报文。

When the Normal Operation State is entered from Ready Sleep State, the CanNm module shall start transmission of Network Management PDUs immediately.

如果节点处于正常运行状态并且NM-Timeout定时器超时，CAN网络管理模块应开启（重新开启）NM-Timeout定时器。

When the NM-Timeout Timer expires in the Normal Operation State, the CanNm module shall (re-)start the NM-Timeout Timer.

如果节点处于正常运行状态并且不再需要网络通信，CAN网络管理模块应从正常运行状态进入休眠就绪状态。

When the network is released and the current state is Normal Operation State, the CanNm module shall leave Normal Operation State and enter the Ready Sleep state.

如果节点处于正常运行状态并且收到的网络管理报文中重复报文标志位置位，CAN网络管理模块应从正常运行状态进入重复报文状态。

If Repeat Message Request Bit is received in the Normal Operation State, the CanNm module shall leave Normal Operation State and enter the Repeat Message State.

如果节点处于正常运行状态并且其他模块（比如ComM）调用重复报文请求，CAN网络管理模块应进入重复报文状态，置位重复报文请求标志位。

If the other module (e.g. ComM) call CanNm for Repeat Message Request in the Normal Operation State, the CanNm module shall enter the Repeat Message State, set the Repeat Message Bit and start the immediate NM message transmission.

3.2.3.2 休眠就绪状态 Ready Sleep State

休眠就绪状态的目的是如果网络中有任意其他节点需要保持唤醒状态，那么本节点应保持在休眠就绪状态，而不是进入准备总线休眠模式。

The Ready Sleep State ensures that any node in the network management cluster waits with transition to the Prepare Bus-Sleep Mode as long as any other node keeps the network management cluster awake.

如果节点从重复报文状态或正常运行状态进入休眠就绪状态，CAN网络管理模块应停止发送网络管理报文。

When the Ready Sleep State is entered from Repeat Message State or Normal Operation State, the CanNm module shall stop transmission of Network Management PDUs.

如果节点处于休眠就绪状态并且NM-Timeout超时，CAN网络管理模块应进入准备总线休眠模式。

When the NM-Timeout Timer expires in the Ready Sleep State, the CanNm module shall enter the Prepare Bus-Sleep Mode.

当节点处于休眠就绪状态，如果对网络通信有需求，CAN网络管理模块应进入正常运行状态。

When the network is requested and the current state is the Ready Sleep State, the CanNm module shall enter Normal Operation State.

当节点处于休眠就绪状态，如果收到的网络管理报文中重复报文请求标志位置位，CAN网络管理模块应从休眠就绪状态进入重复报文状态。

If Repeat Message Request Bit is received in the Ready Sleep State, the CanNm module shall leave Ready Sleep State and enter the Repeat Message State.

当节点处于休眠就绪状态，如果其他软件模块调用重复报文请求，CAN网络管理模块应进入重复报文状态，置位重复报文请求标志位。

If the other module calls CanNm for Repeat Message Request in the Ready Sleep State, the CanNm module shall enter the Repeat Message State, set the Repeat Message Bit and start immediate NM message transmission.

3.3 网络管理帧格式 NM message format

表1展示了8字节网络管理报文的格式，其中节点ID占用第一字节，控制位向量占用第二字节。其余6字节用作自定义数据，具体定义参考CAN通信矩阵。自定义数据中未使用的位用0填充。

The table 1 below shows the format of the Network Management message with 8 bytes where source node identifier is located in the first byte and the control bit vector at the second byte. The remaining 6 bytes are used as user data which are used to transmit user-defined information and can be read or written by application. The table 1 describes the layout of CAN NM message.

CAN FD总线上传输的网络管理报文数据长度码应固定为8字节，其中CANFD和CAN报文的网络管理格式相同。如果ECU收到的网络管理报文长度不是8字节，ECU应将其忽略。

The DLC of Network Management messages on CAN FD shall be 8 bytes. When ECU receives Network Management messages with DLC not equal to 8, this message shall be ignored.

表1 CAN网络管理报文格式 Table 1 CanNm Message Format

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Byte 7	User data 5							
Byte 6	User data 4							
Byte 5	User data 3							
Byte 4	User data 2							
Byte 3	User data 1							
Byte 2	User data 0							
Byte 1	Control Bit Vector							
Byte 0	Source Node Identifier							

每个ECU在其连接的每路CAN或CAN FD接口都会分配一个源节点ID。 一般此源节点ID和对应的网络管理报文CAN ID有如下关系：源节点ID = CAN ID的低8位。比如ECU在某个通道的网络管理报文CAN ID是0x521，那么对应的源节点ID是0x21。每个节点都需要能接收CANID在0x500-0x57F之间的网络管理报文。

Every ECU with CAN or CAN FD interface will be asigned a Source Node Identifier on each channel connected to the ECU. Generally the Source Node Identifier and corresponding CAN Identifier of NM message has the following relation: Source Node Identifier = Lower 8 bits of CAN Identifier. For example if the CAN ID of NM message is 0x521 on one channel, then the Source Node Identifier shall be 0x21. Every node shall be able to receive NM messages with CAN ID range 0x500 – 0x57F.

表2描述了控制位向量的格式：

The table 2 describes the format of the Control Bit Vector:

表2 控制位向量格式 Table 2 Control Bit Vector Format

	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
CBV	Reserved	Reserved	Reserved	Active Wakeup Bit	Reserved	Reserved	Reserved	Repeat Message Request

控制位向量由如下位组成：

The CBV(Control Bit Vector) shall consist of:

Bit 0: 重复报文请求位 Repeat Message Request

- 0:未请求重复报文状态 Request Message State not requested
- 1:请求重复报文状态 Request Message State Requested

Bit 4: 主动唤醒位 Active Wakeup Bit

- 0: 节点没有唤醒网络（被动唤醒）Node has not woken up the network(passive wakeup)
- 1:节点唤醒网络（主动唤醒）Node has woker up the network(active wakeup)

其中User Data 0的bit0被定义为节点重复报文状态指示位，User Data的其他bit的定义详见通信矩阵。

The bit 0 of User data 0 is defined as RepeatSts and refer to the matrix file for the definition of the remaining User data bits.

- 0x0：节点不在重复报文状态 Not in Repeat Message State;
- 0x1：节点处于重复报文状态In Repeat Message State。

如果CAN网络管理由于本地唤醒事件（也即主动唤醒）从总线休眠模式或准备总线休眠模式进入网络模式，CAN网络管理模块应置位控制位向量中的主动唤醒标志位。

If the CanNm performs a state change from Bus Sleep Mode or Prepare Bus Sleep Mode to Network Mode due to a local network request (i.e. due to an active wakeup), the CanNm shall set the ActiveWakeupBit in the CBV.

如果CAN网络管理离开网络模式，应清除控制位向量中的主动唤醒标志位。

If the CanNm module leaves the Network Mode, the CanNm module shall clear the ActiveWakeupBit in the CBV.

网络管理报文对应的CAN ID在DBC或arxml格式文件中定义。

CAN Identifier of NM message will be specified in DBC or arxml file.

3.4 通信调度机制 Communication scheduling

3.4.1 网络管理报文调度机制 NM message scheduling

CAN网络管理模块应支持周期发送报文模式，该模式下CAN网络管理模块应周期发送网络管理报文。该模式只适用在重复报文状态和正常运行状态下。

The CanNm module shall provide the periodic transmission mode. In this transmission mode the CanNm module shall send Network Management PDUs periodically. The periodic transmission mode is only used in Repeat Message State and Normal Operation State.

如果不是通过本地唤醒事件进入重复报文状态或者参数CanNmImmediateNmTransmissions值是0，在进入重复报文状态后，节点应延迟发送网络管理报文，延迟时间通过参数CanNmMsgCycleOffset配置。在发出第一帧网络管理报文后，CAN网络管理模块应使用参数CanNmMsgCycleTime作为网络管理报文周期。如果从重复报文状态进入休眠就绪状态，节点应停止发送网络管理报文。如果从重复报文状态进入正常运行状态，节点应继续发送网络管理报文。此需求参考图3。

If the Repeat Message State is not entered via local network request OR CanNmImmediateNmTransmissions is zero the transmission of NM PDU shall be delayed by CanNmMsgCycleOffset after entering the repeat message state. After the first transmission, the CanNm shall use CanNmMsgCycleTime as cycle time. If CanNm enters Ready Sleep State after Repeat Message State, stop sending NM message. If CanNm enters Normal Operation State after Repeat Message State, keep sending NM message. See figure 3 for this requirement.

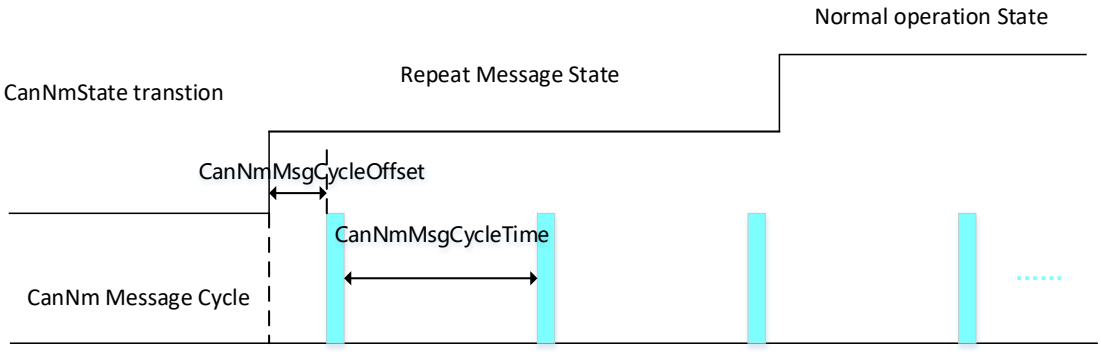

图3 网络管理报文正常发送模式 Figure 3 Normal NM message transmission

如果节点由于本地网络通信请求从总线休眠模式或准备总线休眠模式进入重复报文状态，且参数CanNmImmediateNmTransmissions值大于0，网络管理报文周期应该使用参数CanNmImmediateNmCycleTime的值。第一帧网络管理报文应尽快发出且之后使用参数CanNmImmediateNmCycleTime的值作为网络管理报文周期。

When entering the Repeat Message State from Bus Sleep Mode or Prepare Bus Sleep Mode because of local network request and if CanNmImmediateNmTransmissions is greater zero, the NM PDUs shall be transmitted using CanNmImmediateNmCycleTime as cycle time. The transmission of the first NM PDU shall be triggered as soon as possible. After the transmission the CanNm shall transmit NM PDUs using CanNmImmediateNmCycleTime as cycle time. The CanNmMsgCycleOffset shall not be applied in this case.

节点以周期CanNmImmediateNmCycleTime发送网络管理报文的次数是CanNmImmediateNmTransmissions（含第一帧），之后应以参数CanNmMsgCycleTime值作为网络管理报文周期。网络管理报文快发模式参考图4。

If NM PDUs shall be transmitted with CanNmImmediateNmCycleTime, CanNm shall ensure that CanNmImmediateNmTransmissions (including first immediate transmission) with this timing are requested succesfully. Afterwards if CanNm enter Normal Operation State CanNm shall continue transmitting NM PDUs using the CanNmMsgCycleTime as cycle time. See figure 4 for the immediate NM PDU transmission.

节点从休眠就绪状态进入正常运行状态后，应立刻开始发送网络管理报文（10ms 以内）。

If Normal Operation State is entered from Ready Sleep State the transmission of NM PDUs shall be started immediately.

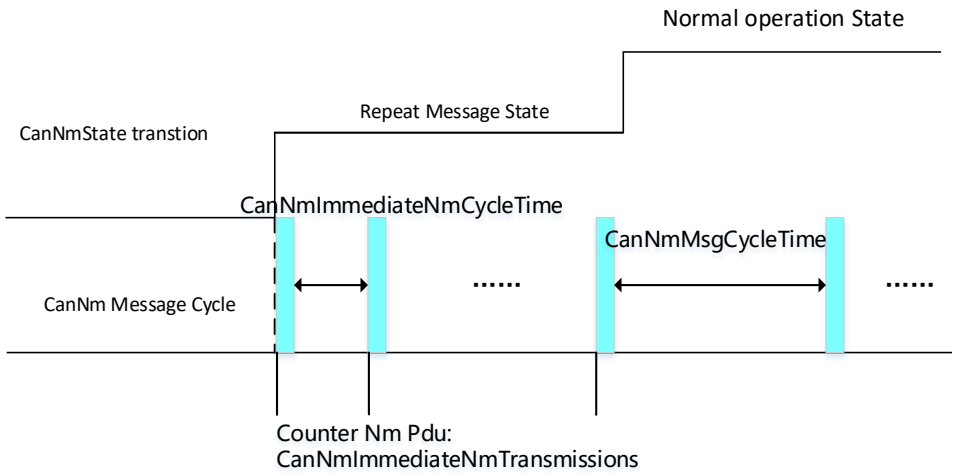

图4 网络管理报文快速发送模式 Figure 4 Immediate NM message transmission

表3展示了不同运行模式下网络管理报文行为。

See the table 3 for different behaviors of NM message in different operation modes.

表3 不同运行模式下NM报文收发行为 Table 3 behaviors of NM frame in different modes

Operation Modes	NM message	
	Tx	Rx
Bus-Sleep Mode	N	Y
Prepare Bus-Sleep Mode	N	Y

Network Mode	Repeat Message State	Y	Y
	Normal Operation State	Y	Y
	Ready Sleep State	N	Y

节点应支持通过UDS $28服务使能或禁止网络管理报文的发送。当网络管理报文发送被禁止，CAN网络管理模块应停止NM-Timeout定时器。当网络管理报文发送被重新使能，CAN网络管理模块应重新开始NM-Timeout定时器。表4列出了对CAN网络管理相关参数值的要求。

Transmission of NM PDUs shall be able to be disabled and enabled by the UDS Communication Control service($28). If the NM PDU transmission is disabled, CanNm shall stop the NM-Timeout Timer. When the NM PDU transmission is enabled, CanNm shall restart the NM-Timeout Timer. Table 4 lists the required value of network management parameters.

表4 网络管理定时参数值 Table 4 NM Timing Parameter value

Parameter name	Value	Tolerance	Description
CanNmImmediateNmTransmissions	40	/	Count of immediate NM messages after CanNm enter Repeat Message State 节点进入重复报文状态后网络管理快发报文的数量
CanNmImmediateNmCycleTime	0.02s	±10%	Time between two consecutive immediate NM messages 两个连续网络管理快发报文的时间间隔
CanNmRepeatMessageTime	1s	±10%	Timeout for Repeat Message State 节点处在重复报文状态的时间
CanNmMsgCycleTime	0.5s	±10%	Nominal time between two consecutive NM messages 两个连续网络管理正常报文的时间间隔
CanNmWaitBusSleepTime	4s	±10%	Typical time of staying in Prepare Bus-Sleep Mode before transition into Bus-Sleep Mode shall take place 在进入总线休眠模式前，节点在准备总线休眠模式停留的时间
CanNmTimeoutTime	3s	±10%	Typical time of staying in the Ready Sleep State before transition into the Prepare Bus-Sleep Mode is initiated. 在进入准备总线休眠模式前，节点应该在休眠就绪状态停留的时间
CanNmMsgCycleOffset	0-0.01s	±10%	Time offset in the periodic transmission node. 周期传输模式下第一帧网络管理报文的发送延时

ECU必须以不超过10ms（推荐5ms）的周期处理网络管理状态机的状态切换。ECU在Prepare Bus Sleep Mode收到NM报文后，应尽可能在下个任务周期进入Repeat Message State，最晚需要在2个任务周期内完成状态切换，参考图5说明。

ECU must handle the network management statemachine transition in a task cycle of no more than 10ms (5ms recommended). After ECU receives an NM message in Prepare Bus Sleep Mode, ECU can preferably enter Repeat Message State in the next task cycle and this transition must be finished within the next 2 cycles at the latest, as described in Figure 5.

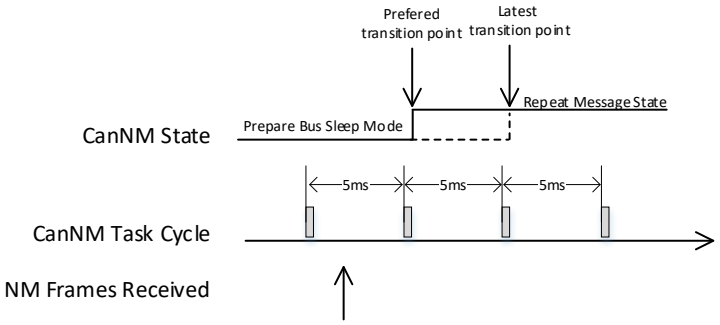

图5 NM任务周期和状态迁移 Figure 5 NM task cycle and state transition

3.4.2 应用报文收发机制 APP message scheduling

APP报文包括除了网络管理和诊断报文外的其他所有报文。这些报文仅在网络管理处于网络模式时可以收发。所有APP报文都应能通过UDS通讯控制服务控制使能和禁止。如果XCP和CCP报文独占一个通道，在小米网络工程师同意后，XCP和CCP报文可以不受UDS通信控制服务的控制。

APP messages shall include all except NM messages and diagnostic messages. These messages shall only be transmitted and received when CanNm is in Network Mode. All APP messages shall be able to enabled and disabled by UDS Communication Control service. If XCP and CCP messages are transmitted on the exclusive channel, these XCP and CCP messages could continue to be sent even if UDS Communication Control service disables the Tx and Rx of APP messages after agreement of Xiaomi network engineer.

表5列出了不同运行模式下APP报文的行为。

See the table 5 for different behaviors of APP messages in different operation modes.

表5 不同运行模式下APP报文的收发行为Table 5 behaviors of APP messages in different modes

Operation Modes		APP message	
		Tx	Rx
Bus-Sleep Mode		N	NC(NotCare)[(1)]
Prepare Bus-Sleep Mode		N	Y
Network Mode	Repeat Message State	Y	Y
	Normal Operation State	Y	Y
	Ready Sleep State	Y	Y

注（1）：ECU 在 CAN 通道处于 Bus-Sleep Mode 时是否对 APP 报文做 Acknowledge 不做限制。
Note(1): It’s not constrained whether the APP messages are acknowledged or not when the channel is in Bus-Sleep Mode.

3.5 ECU 错误处理 ECU Error handling

ECU处于Bus Off状态时，不应影响网络管理状态机的转换，两者以并行模式存在。过程如下：

1）当ECU处于重复报文状态Repeat Message State状态，出现Bus off故障或其它通信异常情况时，ECU的网络状态按照原逻辑正常跳转，不对错误情况进行特殊处理；

2）当ECU处于正常工作状态（Normal Operation State），出现Bus off情况或其它通信异常情况时，ECU的网络状态需要保持在Normal Operation State，NM Timeouttimer超时后，需要重启NM Timeouttimer；

3）当ECU处于休眠就绪状态(Ready Sleep State)，出现Bus off情况或其它通信异常情况，ECU的网络状态按照原逻辑正常跳转，不对错误情况进行特殊处理。

4）对于网关节点（VCCD），当CAN通道处于Normal Operation State/Repeat Message State，且尝试发送NM以外报文但没有其他节点Acknowledge持续时间超过100ms（±10%），此时网关节点应取消未被Acknowledge的报文，并优先发送NM报文。

When ECU is in bus off state, it shall not affect the conversion of network management state machine. The two exist in parallel mode. The process is as follows:

1) When the ECU is in repeat message state, bus off fault or other abnormal communication conditions occur, the network state of the ECU will jump normally according to the original logic, and no special treatment will be given to the error condition;

2) When ECU is in normal operation state and bus off condition or other abnormal communication condition occurs, the network state of ECU needs to be kept in normal operation state. After nm timeouttimer times out, nm timeouttimer needs to be restarted;

3) When the ECU is in the ready sleep state, bus off or other abnormal communication occurs, the network state of the ECU will jump normally according to the original logic, and no special treatment will be given to the error.

4) When GW(VCCD) is sending the other messages than NM messages in Normal Operation State/Repeat Message State and no other nodes give Acknowledge within 100ms(±10%), GW(VCCD) should cancel the message not acknowledged and try to send firstly the NM message and then the other messages.

3.6 ECU 诊断报文的处理 ECU Processing of diagnostic message

对于Autosar网络管理节点，ECU对于诊断报文的处理机制如下：

1） 当ECU处于睡眠状态（Bus Sleep Mode），不应被诊断报文唤醒；

2） 当ECU处于重复报文状态（Repeat Message State），收到诊断报文的请求且Repeat Message Timer超时后， ECU应进入正常运行状态（Normal Operation State），并维持在正常运行状态（Normal Operation State）。如果此诊断请求使得ECU当前诊断会话保持默认会话，则维持时间持续到诊断请求处理结束为止。如果此诊断请求使得ECU当前诊断会话从默认会话切换至非默认会话，则维持时间持续到ECU从非默认会话切换至默认会话为止。

3） 当ECU处于正常运行状态（Normal Operation State），收到诊断报文的网络请求，应维持在正常运行状态（Normal Operation State）。如果此诊断请求使得ECU当前诊断会话保持默认会话，则维持时间持续到诊断请求处理结束为止。如果此诊断请求使得ECU当前诊断会话从默认会话切换至非默认会话，则维持时间持续到ECU从非默认会话切换至默认会话为止。

4） 当ECU处于休眠就绪状态(Ready Sleep State)，收到诊断报文的网络请求，ECU需要进入到正常运行状态（Normal Operation State）,维持在正常运行状态（Normal Operation State）。如果此诊断请求使得ECU当前诊断会话保持默认会话，则维持时间持续到诊断请求处理结束为止。如果此诊断请求使得ECU当前诊断会话从默认会话切换至非默认会话，则维持时间持续到ECU从非默认会话切换至默认会话为止。

5） 当ECU处于准备总线休眠模式（Prepare Bus Sleep Mode），收到诊断报文的网络请求，ECU不应请求网络，也不应发出诊断应答。

6） 当ECU完成诊断服务且睡眠条件满足，应能够再次进入睡眠状态。

For the AUTOSAR network management node, the processing mechanism of ECU for diagnostic message is as follows:

1) When ECU is in bus sleep mode, it shall not be awakened by diagnostic message;

2) When the ECU is in the repeat message state, after receiving the request of diagnostic message and the repeat message timer times out, the ECU shall enter the Normal Operation State and maintain it in the Normal Operation State. If the received diagnostic request keeps the current default diagnostic session, ECU shall stay in Normal Operation State until the diagnostic request is finished. If the received diagnostic request causes the transition from default sesstion to non-default session, ECU shall stay in Normal Operation State until the active session transit into default session from non-default session.

3) When ECU is in Normal Operation State and receives the network request of diagnostic message, it shall be maintained in Normal Operation State. If the received diagnostic request keeps the current default diagnostic session, ECU shall stay in Normal Operation State until the diagnostic request is finished. If the received diagnostic request causes the transition from default sesstion to non-default session, ECU shall stay in Normal Operation State until the active session transit into default session from non-default session.

4) When the ECU is in the ready sleep state and receives the network request of the diagnostic message, the ECU needs to enter the Normal Operation State and maintain it in the Normal Operation State. If the received diagnostic request keeps the current default diagnostic session, ECU shall stay in Normal Operation State until the diagnostic request is finished. If the received diagnostic request causes the transition from default sesstion to non-default session, ECU shall stay in Normal Operation State until the active session transit into default session from non-default session.

5) When ECU is in prepare bus sleep mode and receives the network request of diagnostic message, ECU shall not request the network and shall not send diagnostic response.

6) When the ECU completes the diagnostic service and the sleep conditions are met, it shall be able to enter the sleep state again.

3.7 ECU 启动 ECU Startup

如果ECU被硬线IO或内部定时器唤醒且内部功能模块需要CAN总线通信，ECU应通过本地唤醒事件进入网络模式（即主动唤醒）。然后ECU应在T_init时间内发出第一帧网络管理报文。之后ECU应在T_messageStart时间内发出第一帧APP报文，之后应该在T_networkStart时间内将所有周期性应用层报文都发送至少一次。图6描述了此需求。

When ECU is wakeup by hardware IO or internal timer and CAN communication is needed by internal function modules, ECU shall enter Network Mode via local network request (i.e. active wakeup). Then ECU shall send out the first NM message within T_init. After sending the first NM message, the transmission of APP messages shall begin within T_messageStart. All cyclic APP messages shall be sent for at least once within T_networkStart since the first APP message is sent. See figure 5 for this requirement.

ECU应能够被网络管理报文唤醒，并在确认是有效的网络管理报文后开始发送网络管理报文和APP报文。

ECU shall be able to be wakeup when valid NM PDUs are received. After validating NM message ECU shall begin to send NM messages and APP messages.

ECU被唤醒后如果在T_wakeupTimeout时间内没有任何有效的内部或网络唤醒源被确认，应重新进入休眠状态且在唤醒期间不发送任何网络管理和APP报文。

If no any valid internal or network wakeup sources after T_wakeupTimeout, ECU shall go back to sleep without sending any NM or APP messages.

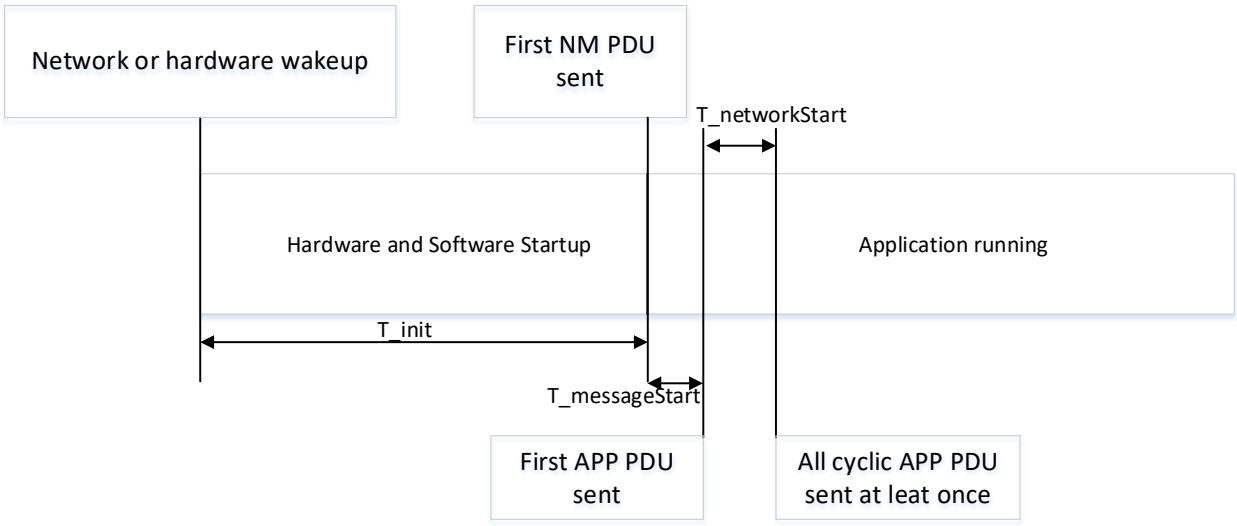

图6 ECU启动时序图 Figure 6 ECU Startup Timing Sequence

表6展示了ECU启动相关时间参数值：

See table 6 for the value of ECU startup timing parameter

表6 启动时间参数值 Table 6 Startup Timing Parameter value

参数 Parameter name	数值(毫秒) Value (ms)	容差 Tolerance	描述 Description

T_init	150	+10%	网络或者硬件唤醒事件到ECU发出第一帧网络管理报文的最大时间 Max time between network or hardware wakeup event and the first NM PDU sent out
T_messageStart	10	+10%	ECU唤醒后第一帧网络管理报文到第一帧应用报文的间隔 Max time between the first NM PDU sent out and the first APP PDU sent out
T_networkStart	150	+10%	ECU唤醒后在发出第一帧网络管理报文后，至所有周期性报文至少发送一次的最大时间 Max time to send all APP cyclic messages for at least once since the first NM memssage is sent after wakeup.
T_wakeupTimeout	1500	+10%	ECU唤醒后确认有效唤醒源最大时间 Max time for wakeup validation timeout