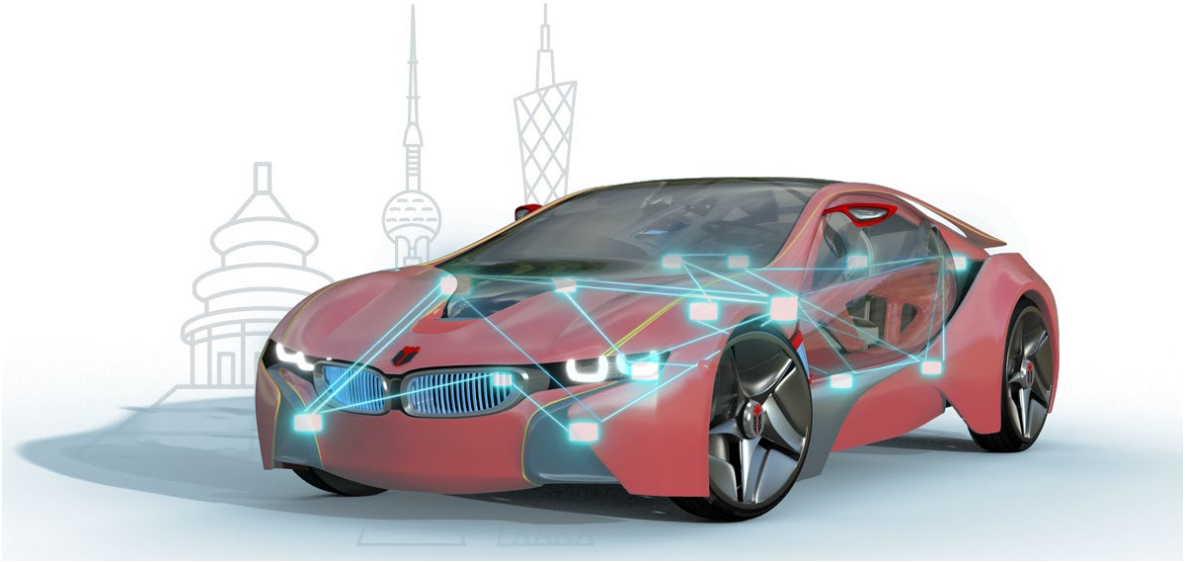
知从青龙 ETHERNET BOOTLOADER RENESAS RH850U2A 产品手册 ZC.QINGLONG ETHERNET BOOTLOADER PRODUCT MANUAL BASED ON RENESAS RH850U2A

知从青龙 BootLoader

ZC.QingLong BootLoader



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知从青龙 BootLoader

ZC.QingLong BootLoader

1 功能概述 FUNCTIONAL OVERVIEW

知从青龙 BootLoader 是由知从科技自主研发的程序刷新软件(BootLoader)。使用知从青龙 BootLoader 的控制器，可以通过 CAN、LIN、SPI、UART、Ethernet 等通信方式实现应用程序的更新功能。知从青龙 BootLoader 已支持 NXP、Infineon、Renesas、ST 等多家芯片，并且支持多家整车厂程序刷新规范，可提供定制开发服务。

ZC.QingLong BootLoader is a program flashing software (BootLoader) independently developed by ZC Technology. For controllers using the ZC.QingLong BootLoader, the update function of application programs can be achieved through communication methods such as CAN, LIN, SPI, UART, and Ethernet. The ZC.QingLong BootLoader already supports chips from multiple manufacturers including NXP, Infineon, Renesas, and ST. Moreover, it is compatible with the program flashing specifications of multiple vehicle manufacturers and can provide customized development services.

在知从青龙 BootLoader 的基础上，知从青龙 Ethernet OTA 基于 Renesas RH850U2A 平台，结合 Ethernet 诊断协议与 DOIP 功能实现了 Ethernet 刷写功能，控制器可以通过 Ethernet 通信方式执行 OTA 刷新，并在此基础上支持适配安全启动、安全刷写等信息安全功能以及 AB 分区备份、版本回滚等 OTA 功能，提高程序刷新的效率和安全性。知从青龙 Ethernet OTA 同样支持多家整车厂的 OTA 规范，并提供定制开发服务。

Based on the ZC.Qinglong BootLoader, the ZC.Qinglong Ethernet OTA, which is based on the Renesas RH850U2A platform, combines the Ethernet diagnostic protocol with the DOIP function to achieve the Ethernet flashing function. The controller can execute OTA flashing through Ethernet communication. On this basis, it supports and adapts to information security functions such as secure boot and secure flashing, as well as OTA functions such as AB partition backup and version rollback, improving the efficiency and security of program flashing. The ZC.Qinglong Ethernet OTA also supports the OTA specifications of multiple vehicle manufacturers and provides customized development services.

2 应用领域 APPLICATION FIELD

知从青龙 Ethernet OTA 可应用于使用 RH850U2A 系列芯片的控制器程序刷新功能。支持的控制器包括:

The ZC.Qinglong Ethernet OTA can be applied to the program flashing function of controllers using the RH850U2A series of chips. The supported controllers include:

- 车身系统 Body Systems Vehicle
  车身控制器、空调控制器、车门控制器、网关等
  Domain controllers, zone controllers, gateways, etc.
- 动力系统 Power Systems
  电池管理系统等
  Battery management systems, etc
- 底盘系统 Chassis Systems
  电动助力转向系统、制动防抱死系统、电气稳定系统等
  Electric power steering systems, anti-lock braking systems, electronic stability systems, etc

3 配置环境 CONFIGURATION ENVIRONMENT

配置环境 Configuration Environment	
Hardware (Chip)	RH850U2A8
Compilers Supported	GreenHills For RH850 (comp 202015 / multi 716 2020)
Debugger	Isystem (IC5000 / IC5700)

HighTec 编译器 HighTec Compiler	
编译选项 **Compiler Options**	-bsp generic {optgroup=GhsCompilerOptions} -cpu=rh850g4mh {optgroup=GCoresOptions} -cpu=rh850g4mh #:sourceDir=. -large_sda -Olink -Onone -object_dir=objs/AppDemo -ghsmc_core_count=1 -ghsmc_file=./DemoPrj/Debug/MultiCoreConfiguration.ghsmc -ignore_debug_references -dwarf2 -no_init_ram_at_startup -G -e=_RESETVECT {optgroup=GhsCommonOptions} -o ./output/Bootloader.elf {optgroup=GhsCompilerOptions} -srec=./output/Bootloader.s19
链接选项 **Linker Options**	-L..\libs -llibCdd.a

4 开发背景 DEVELOPMENT BACKGROUND

智能化和网联化是未来汽车的发展方向。智能汽车的快速发展，改变了汽车的价值，伴随着用户体验需求的攀升，系统软件变得愈发重要，软件定义汽车成为不可逆转的趋势。

Intelligent and connected vehicles are the future direction of the automotive industry. The rapid development of smart cars has changed the value of cars. With the rise of user experience needs, system software has become increasingly important, and the trend of software-defined vehicles has become irreversible.

软件定义汽车（Software Defined Vehicles，简称 SDV）核心思想是：决定未来汽车的是以人工智能为核心的软件技术，而不再是汽车的马力大小、是否真皮座椅、机械性能好坏，而这也将成为汽车行业普遍的发展趋势。汽车行业的产业结构构建正重走电脑和手机行业的发展路径，将来衡量汽车优劣的标准将从“硬件”水平转化为智能化水平的高低和软件服务的好坏。

The core idea of Software Defined Vehicles (SDV) is that the future of cars will be determined by software technology centered on artificial intelligence, rather than the size of the car's horsepower, whether it has genuine leather seats, or the quality of its mechanical performance. This will become a common development trend in the automotive industry. The industrial structure of the automotive industry is following the development path of the computer and mobile phone industries, and the standard for measuring the quality of cars will shift from the "hardware" level to the level of intelligence and the quality of software services.

在汽车智能化发展过程中，尽管软件的重要性及占比不断提升，但整车研发周期却在无形中缩短，因此由于软件漏洞引发汽车召回的风险持续攀升。目前高端汽车的整车代码量已经突破 1 亿行，即使按照 CMMI（Capability Maturity Model Integration，能力成熟度集成模型）5 级的最高软件标准进行控制，代码缺陷率仍为 0.32‰，潜在问题的规模不容小觑。而召回事件，需要整车厂付出巨大的直接和间接成本。

In the process of automotive intelligence development, although the importance and proportion of software continue to increase, the research and development cycle of the whole vehicle is invisibly shortened, so the risk of car recalls caused by software vulnerabilities continues to rise. At present, the total code amount of high-end cars has exceeded 100 million lines. Even if controlled according to the highest software standard of CMMI (Capability Maturity Model Integration) level 5, the code defect rate is still 0.32‰, and the scale of potential problems is not to be underestimated. Recall events require car manufacturers to pay huge direct and indirect costs.

对于处在发展中的行业而言，面对智能汽车行业发展大趋势，类似于特斯拉一样的系统更新功能必将成为行业可持续发展的前提和基础，FOTA（Firmware Over-The-Air，移动终端空中下载软件升级）也就成为解决软件漏洞、进行智能汽车配件升级的最佳解决方案之一。

For industries in development, facing the major trend of the development of smart cars, system update functions similar to those of Tesla will inevitably become the premise and foundation for the sustainable development of the industry. FOTA (Firmware Over-The-Air) has thus become one of the best solutions for addressing software vulnerabilities and upgrading smart car components.

FOTA 无线升级，是指通过云端为具有连网功能的终端设备提供固件升级服务，用户使用网络以按需、易扩展的方式获取智能终端系统升级包，并通过 FOTA 进行云端升级，完成系统修复和优化。汽车制造商和供应商通过 FOTA 专业的升级方案，能方便快捷地实现汽车 ECU、系统版本等迭代，保证系统安全、快速升级，让用户在不更换硬件设备的前提下，体验新功能。

FOTA wireless upgrades refer to providing firmware upgrade services for terminal devices with networking capabilities through the cloud. Users use the network to obtain smart terminal system upgrade packages on demand and in an easy-to-expand manner, and upgrade through FOTA to complete system repairs and optimizations. Car manufacturers and suppliers can quickly and conveniently achieve iterations of car ECUs, system versions, etc., through professional FOTA upgrade plans, ensuring system security and rapid upgrades, allowing users to experience new functions without replacing hardware equipment.

Ethernet 通常具有较高的数据传输速率，能够支持大量数据的快速传输。这对于 OTA 升级中较大的软件或固件文件来说非常重要，可以显著缩短升级时间，减少用户等待的时长。通过使用 DoIP 协议实现高效的数据传输和灵活的网络架构，为现代车辆诊断提供了可靠的支持，为 OTA 升级需求提供了可靠的远程升级方案，大大降低了车辆更新召回导致的成本。

Ethernet typically offers a high data transfer rate, enabling the rapid transmission of large volumes of data. This is crucial for relatively large software or firmware files during OTA upgrades, as it can significantly reduce the upgrade time and minimize the user's waiting period. By implementing the DoIP for efficient data transfer and a flexible network architecture, it provides reliable support for modern vehicle diagnostics and offers a reliable remote upgrade solution to meet OTA upgrade requirements. This substantially cuts down the costs associated with vehicle updates and recalls.

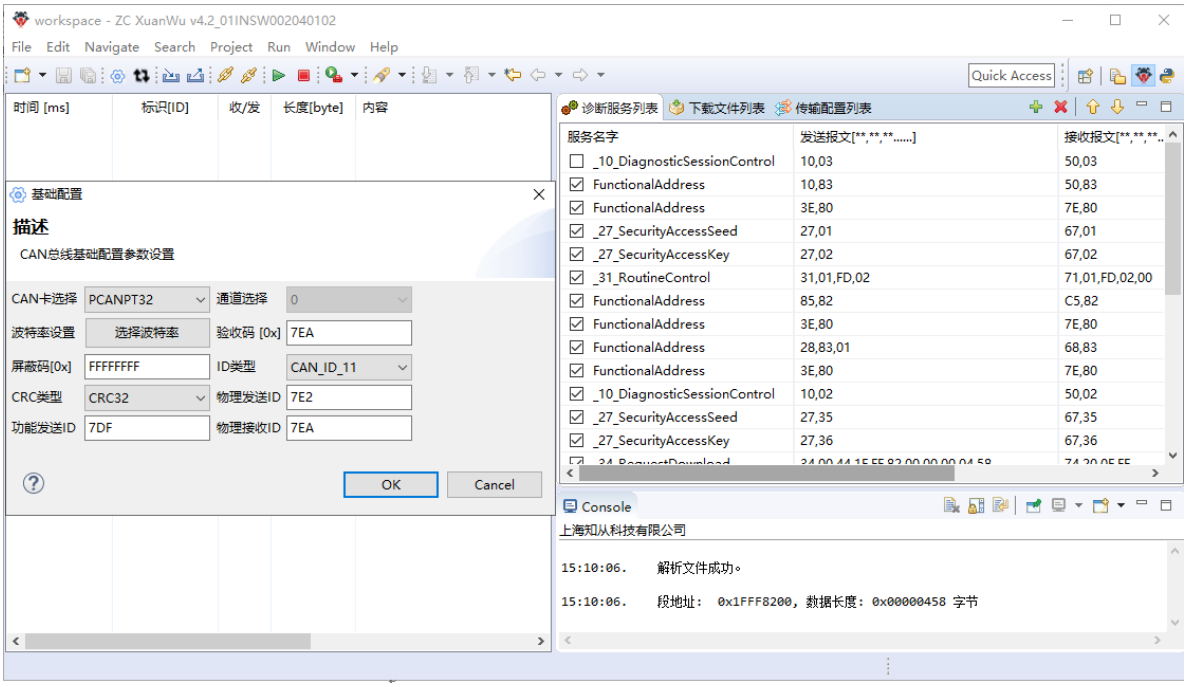
目前，FOTA 已逐渐被认可，并发展成为影响 OEM（Original Equipment Manufacturer，原始设备制造商）和 TSP（Telematics Service Provider，汽车远程服务提供商）决策的车联网新趋势，也是汽车厂商提升用户体验的创新尝试和趋势之一。

At present, FOTA has gradually been recognized and has developed into a new trend of the Internet of Vehicles that affects the decisions of OEMs (Original Equipment Manufacturers) and TSPs (Telematics Service Providers). It is also one of the innovative attempts and trends for car manufacturers to improve user experience.

5 功能描述 FUNCTIONAL DESCRIPTION

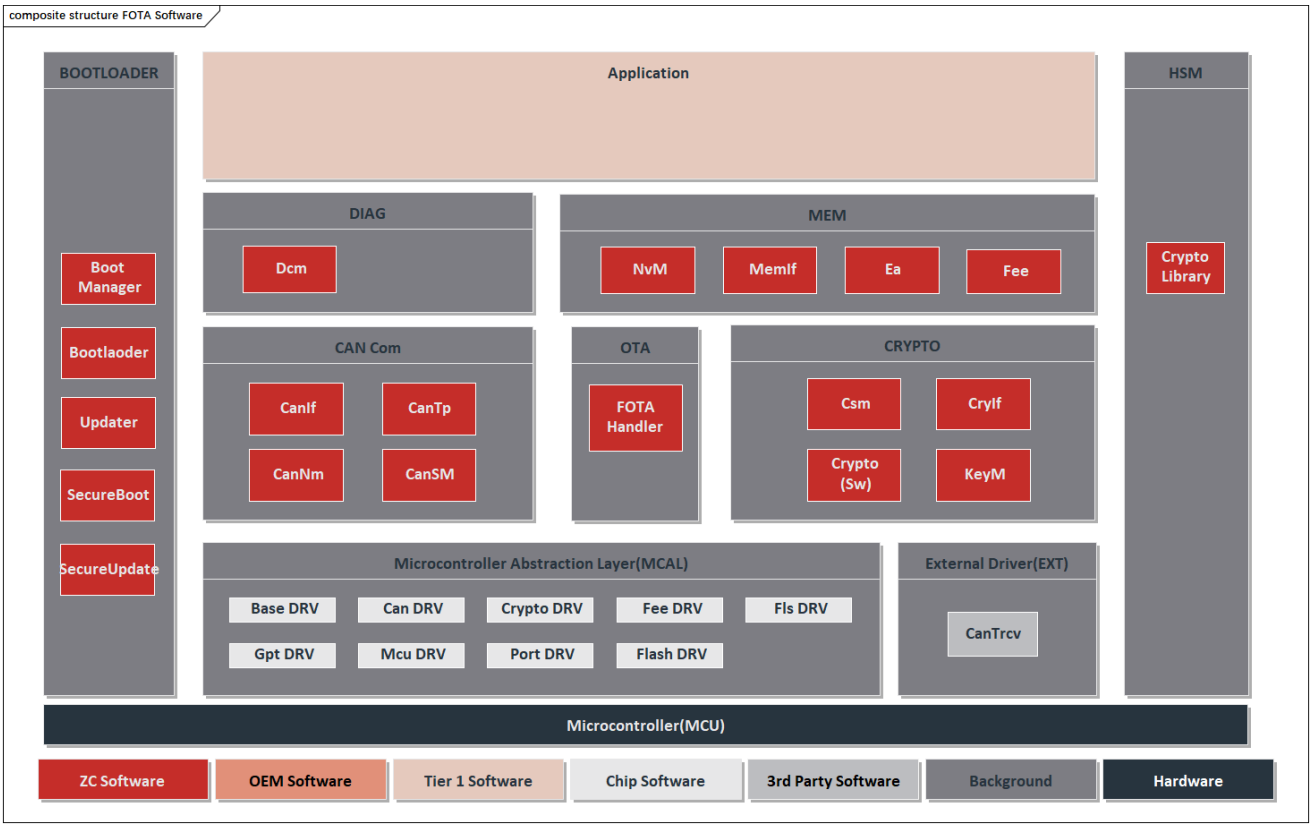
5.1 产品特点 Product Features

- 使用 Ethernet DoIP 协议传输数据，符合 ISO13400 和 ISO14229 规范
  Uses Ethernet DoIP protocol for data transmission, compliant with the ISO 14229 standard.
- 适用于多家整车厂的程序更新规范
  Adaptable to the program update specifications of various car manufacturers.
- 支持多重加密机制，保证数据的安全可靠
  Supports multiple encryption mechanisms to ensure the security and reliability of data.
- 支持应用程序和数据的更新功能
  Offers update capabilities for both applications and data.
- 支持 AB 分区备份功能，保证升级过程原有软件数据的完整性
  Supports AB partition SWAP functionality to ensure the integrity of data during the upgrade process.
- 支持断点续传、智能还原、可回溯的安全机制，保证升级过程安全稳定
  Features safe and stable upgrade processes with mechanisms such as breakpoint resumption, intelligent restoration, and traceability.
- 支持差分还原技术，比普通升级时间提速 90%
  Supports differential restoration technology, which can speed up the upgrade process by 90% compared to standard upgrades.
- 支持整包升级，提供更多的安全保障
  Supports full package upgrades for enhanced security.
- 适配知从玄武程序更新工具，提供完整的程序更新解决方案
  Compatible with ZC.Xuanwu program update tools, providing a comprehensive solution for program updates.



知从玄武—程序更新工具
ZC.XuanWu—Program Update Tool

5.2 软件架构 Software Architecture



FOTA 系统架构
FOTA SYSTEM ARCHITECTURE

知从青龙 Ethernet FOTA 系统架构支持以太网通信场景下的 FOTA 功能，通过 TCP/IP、DoIP、SoAd、Dcm 模块实现 Ethernet 通信 UDS 诊断刷写，并通过适配 Crypto Library 实现各 OEM 规范的信息安全需求。以下为各模块的功能描述：

The Qinglong Ethernet FOTA system architecture supports the FOTA function in Ethernet communication scenarios. It realizes the UDS diagnostic flashing for Ethernet communication through the TCP/IP, DoIP, SoAd, and Dcm modules, and meets the Cybersecurity requirements of various OEM specifications by adapting to the Crypto Library. The following are the function descriptions of each module:

- Bootloader

  BootManager 模块提供 FOTA 启动管理功能，支持适配软硬件 SecureBoot 功能，通过烧录和刷写存储 Bootloader 和 Application 的期望 MAC 值，启动阶段 SecureBoot 通过计算比较 Bootloader 和 Application 的 MAC 执行软件完整性校验，保证软件安全需求。

  The BootManager module provides FOTA startup management functions and supports the adaptation of hardware and software SecureBoot functions. It stores the expected MAC values of the Bootloader and Application through programming and flashing. During the startup phase, SecureBoot performs software integrity verification by calculating and comparing the MACs of the Bootloader and Application to ensure software security requirements.

- Ethernet Com

  DoIP 模块基于 TCP/IP 协议实现 Ethernet 通信收发功能，满足 ISO 13400 标准定义。通过车辆识别、路由激活、诊断消息功能实现 UDS 刷写流程，实现 Ethernet OTA 功能。

  The DoIP module realizes the Ethernet communication sending and receiving functions based on the TCP/IP protocol, meeting the definition of the ISO 13400 standard. It implements the UDS flashing process through vehicle identification, routing activation, and diagnostic message functions, thereby achieving the Ethernet OTA function.

- Crypto、HSM

  Ethernet OTA 支持适配木牛加密库功能，支持非对称加密算法和加密算法结合实现安全刷写功能，适配证书认证功能满足安全诊断功能，适配 HSM 提高信息安全功能的稳定性和校验速度。

  The Ethernet OTA supports the adaptation of the Muniu encryption library functions. It combines asymmetric encryption algorithms with other encryption algorithms to achieve the secure flashing function. It adapts to the certificate authentication function to meet the security diagnostic requirements and adapts to the HSM to improve the stability and verification speed of the Cybersecurity function.

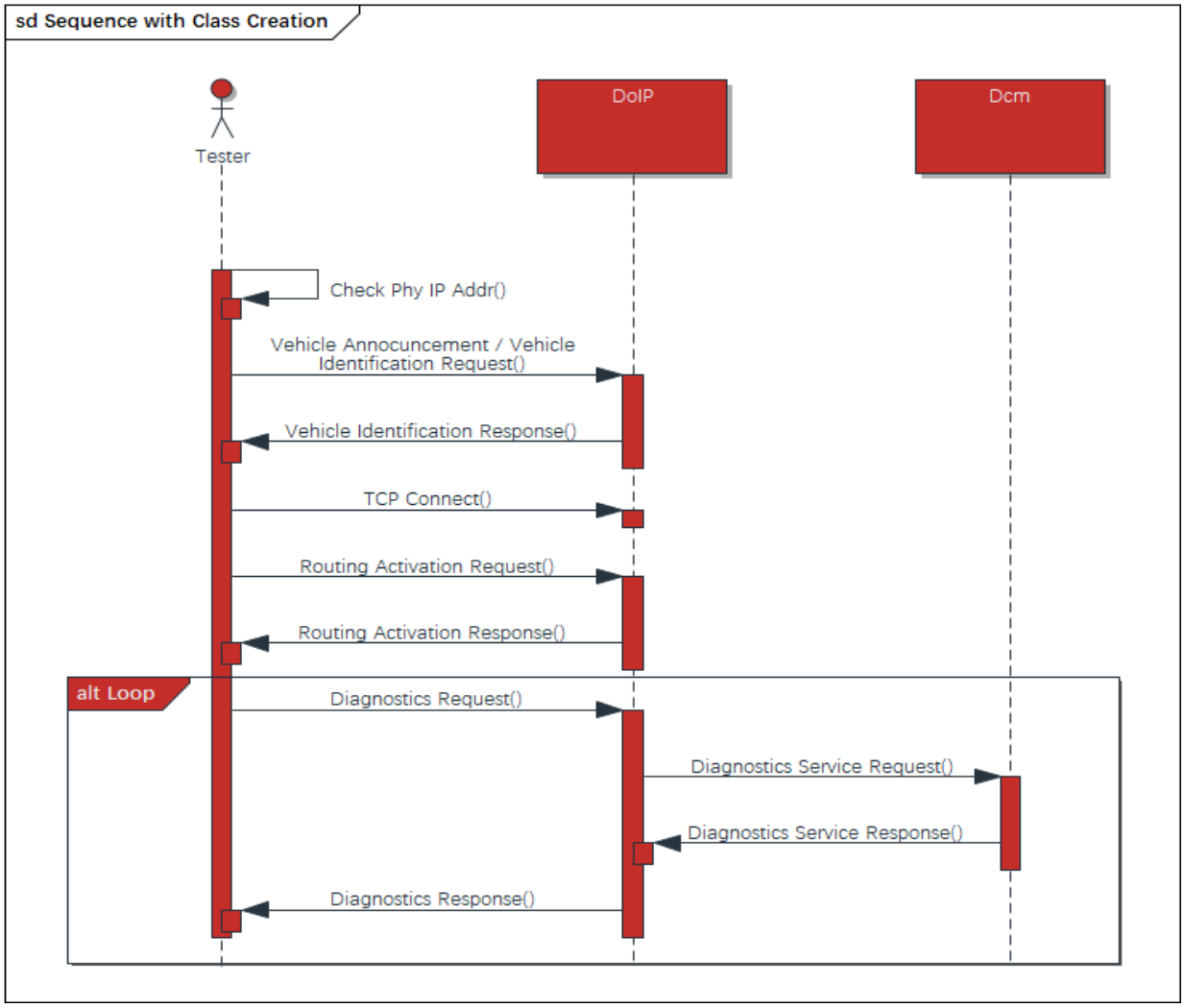
5.3 通信流程 Communication Sequence

外部诊断设备与车内 DoIP 实体通过车辆识别、建立连接、路由激活完成通信连接，并通过发送诊断服务执行 Ethernet OTA 的诊断刷写功能。

The external diagnostic device and the in - vehicle DoIP entity complete the communication connection through vehicle identification, connection establishment, and routing activation, and execute the diagnostic flashing function of Ethernet OTA by sending diagnostic services.

外部诊断设备与车内 DoIP 实体建立通信的流程如下图所示。

The process of establishing communication between the external diagnostic device and the in - vehicle DoIP entity is shown in the following figure.



以太网诊断刷写流程

ETHERNET DIAGNOSTIC FLASHING PROCESS

车辆发现流程的目的是将节点的 DoIP 属性告诉给当前局域网内其它 DoIP 节点。其它 DoIP 节点可根据自己的业务需求，决定是否与其建立连接通讯：

The purpose of the vehicle discovery process is to inform other DoIP nodes within the current local area network of the DoIP attributes of a node. Other DoIP nodes can decide whether to establish a connection and communicate with it according to their own business requirements.

a) 上电后，Client 以广播方式主动发送 Vehicle Announcement Message / Vehicle Identification Request，在消息中携带逻辑地址、VIN、EID 等信息；

a) After powering on, the Client actively sends a Vehicle Announcement Message / Vehicle Identification Request in a broadcast manner, carrying information such as the logical address, VIN (Vehicle Identification Number), and EID (Entity ID) in the message.

b) 收到该消息的 Server 以单播的形式回复 Vehicle Identification Response 消息，其中携带逻辑地址、VIN、EID 等信息。

b) The Server that receives this message replies with a Vehicle Identification Response message in unicast form, which carries information such as the logical address, VIN, and EID.

Client 与 Server 在完成车辆识别后，通过建立 TCP 连接进行 UDS 通信：

After the Client and the Server complete the vehicle identification, they conduct UDS communication by establishing a TCP connection.

a) Client 主动与 Server 建立 TCP 连接；

a) The Client takes the initiative to establish a TCP connection with the Server.

b) Client 发送 Routing Activation Request 消息请求激活路由，Server 根据实际情况同意或者拒绝激活请求，激活结果通过发送 Routing Activation Response 消息告知 Client；

b) The Client sends a Routing Activation Request message to request the activation of the route. The Server agrees or rejects the activation request according to the actual situation, and notifies the Client of the activation result by sending a Routing Activation Response message.

完成路由激活后，上位机通过 DoIP 协议发送诊断刷写请求，按照刷写流程执行 OTA 更新功能。

After the route activation is completed, the host computer sends a diagnostic flashing request through the DoIP protocol and executes the OTA update function according to the flashing process.

5.4 知从玄武刷写工具刷写流程 ZC.Xuanwu Programming Sequence

知从玄武刷写工具已支持 DoIP 通信协议的以太网刷写功能。使用知从玄武刷写工具进行刷写前，需要适配通信接口类型、通信 IP 地址、端口号、源地址 SA、目的地址 TA 等。

The ZC.Xuanwu Flashing Tool already supports the Ethernet flashing function based on the DoIP communication protocol. Before using the ZC.Xuanwu Flashing Tool for flashing, it is necessary to configure the communication interface type, communication IP address, port number, source address (SA), destination address (TA), etc.

玄武刷写工具 DOIP 配置界面

DOIP CONFIGURATION INTERFACE OF THE XUANWU FLASHING TOOL

刷写执行刷写前需要导入预设的 xml 文件，载入对应 OEM 刷写规范的刷写流程，或自行配置刷写流程服务。

Before performing the flashing operation, you need to import a preset XML file to load the flashing process corresponding to the OEM's flashing specifications, or configure the flashing process services by yourself.

诊断服务列表 | 下载文件列表 | 传输配置列表

服务名称	服务子功能或数据	发送报文[**,**,**.....]	接收报文[**,**,**.....]	物理寻址	响应抑制
_22_ReadDataByIdentifier	-	22,F1,93	62,F1,93	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,95	62,F1,95	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,87	62,F1,87	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,75	62,F1,75	TRUE	FALSE
_10_DiagnosticSessionCont...	03_ExtendedSession	10,03	50,03	FALSE	FALSE
_27_SecurityAccessSeed	-	27,01	67,01	TRUE	FALSE
_27_SecurityAccessKey	-	27,02	67,02	TRUE	FALSE
_31_RoutineControl	-	31,01,F0,02	71,01	TRUE	FALSE
_85_ControlDTCSetting	-	85,02	C5,02	FALSE	FALSE
_28_CommunicationControl	-	28,03,03	68,03	FALSE	FALSE
_10_DiagnosticSessionCont...	02_ProgrammingSession	10,02	50,02	TRUE	FALSE
DelayTimer	01_DefaultSession	70,00	50,02	TRUE	FALSE
_27_SecurityAccessSeed	-	27,03	67,03	TRUE	FALSE
_27_SecurityAccessKey	-	27,04	67,04	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,84	62,F1,84	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,80	62,F1,80	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,86	62,F1,86	TRUE	FALSE
_22_ReadDataByIdentifier	-	22,F1,70	62,F1,70	TRUE	FALSE
_2E_WriteDataByIdentifier	01_DefaultSession	2E,F1,84,20,25,01,20,39,2E,31,2E,30,20,20	6E,F1,84	TRUE	FALSE
_34_RequestDownload	-	34,00,44,FD,C0,10,00,00,00,0E,F6	74	TRUE	FALSE
_36_TransferData	path	36,01	76	TRUE	FALSE
_37_TransferExit	-	37	77	TRUE	FALSE
31_RoutineControl	-	31,01,F1,A0,BA,00,07,46	71,01,F1,A0	TRUE	FALSE

玄武刷写工具刷写流程配置界面

FLASHING PROCESS CONFIGURATION INTERFACE OF THE XUANWU FLASHING TOOL

刷写流程开始后，用户可以通过流程报文监控界面观察刷写进度以及刷写过程中出现的错误。

After the flashing process starts, users can observe the flashing progress and any errors that occur during the flashing process through the process message monitoring interface.

时间 [ms]	标识[ID]	收/发	长度[byte]	内容
09:33:49:841	00, 00, 07, 5A,	R	4	74, 20, 00, C8,
09:33:49:892	00, 00, 07, 52,	T	200	36, 01, 02, F4, 91, 10, 00,
09:33:49:921	00, 00, 07, 5A,	R	2	76, 01,
09:33:49:944	00, 00, 07, 52,	T	68	36, 02, D9, FF, A6, C1, DC,
09:33:49:971	00, 00, 07, 5A,	R	2	76, 02,
09:33:49:972	00, 00, 07, 52,	T	1	37,
09:33:49:990	00, 00, 07, 5A,	R	1	77,
09:33:50:003	00, 00, 07, 52,	T	8	31, 01, 02, 02, BB, 77, C2,
09:33:50:012	00, 00, 07, 5A,	R	3	7F, 31, 78,
09:33:50:160	00, 00, 07, 5A,	R	3	7F, 31, 78,
09:33:50:180	00, 00, 07, 5A,	R	5	71, 01, 02, 02, 04,
09:33:50:181	00, 00, 07, 52,	T	4	31, 01, FF, 01,
09:33:50:189	00, 00, 07, 5A,	R	3	7F, 31, 78,
09:33:50:315	00, 00, 07, 5A,	R	5	71, 01, FF, 01, 04,
09:33:50:315	00, 00, 07, 52,	T	2	11, 01,
09:33:50:335	00, 00, 07, 5A,	R	2	51, 01,
09:33:50:335	00, 00, 07, 52,	T	2	10, 03,
09:33:52:338	00, 00, 07, 52,	T	2	10, 03,
09:33:54:337	00, 00, 07, 5A,	R	6	50, 03, 00, 32, 00, C8,
09:33:54:337	00, 00, 07, 52,	T	2	10, 01,
09:33:54:338	00, 00, 07, 5A,	R	6	50, 01, 00, 32, 00, C8,

玄武刷写工具流程报文监控界面

XUANWU FLASHING TOOL PROCESS MESSAGE MONITORING INTERFACE

6 过程文档 PROCESS DOCUMENTATION

开发流程 Development Process	文档描述 Document Description
需求收集 Development Process	顾客的需求文档 Document Description
软件需求分析 Requirement Collection	需求分析 Requirement Analysis
	需求分析规格书 Requirement Analysis Specification
	软件需求追踪表 Software Requirement Traceability Matrix
	客户的问题沟通表 Customer Issue Communication Form
软件架构设计 Software Architecture Design	软件架构说明书 Software Architecture Manual
	软件架构的追踪表 Software Architecture Traceability Table
软件详细设计和单元设计 Software Detailed Design and Unit Design	FOTA 详细设计说明书 FOTA Detailed Design Manual
	配置工具设计 Configuration Tool Design
	软件详细设计追踪表 Software Detailed Design Traceability Table
	FOTA 详细设计评审 FOTA Detailed Design Review
软件单元测试 Software Unit Testing	QAC 分析报告 QAC Analysis Report
	Tessy 测试报告 Tessy Test Report
	软件单元验证策略 Software Unit Verification Strategy
软件集成和集成测试	集成策略 Integration Strategy
	集成手册 Integration Manual

开发流程 Development Process	文档描述 Document Description
Software Integration and Integration Testing	集成测试策略 Integration Test Strategy
	集成测试报告 Integration Test Report
	资源分析报告 Resource Analysis Report
软件认可测试 Software System Testing	FOTA 软件测试报告 FOTA Software Test Report
	FOTA 软件测试报告评审 FOTA Software Test Report Review
发布 Release	发布文档 Release

7 证书 CERTIFICATE

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证书号：软著登字第14035707号

软件名称：知从青龙BootLoader软件
[简称：知从青龙]
V9.1.0

著作权人：上海知从科技有限公司

权利取得方式：原始取得

权利范围：全部权利

登记号：2024SR1631834

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2024年10月29日

知从青龙 BOOTLOADER 软件证书

ZC.QINGLONG BOOTLOADER SOFTWARE CERTIFICATE

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To Be the Global Leading Automotive Basic Software Company