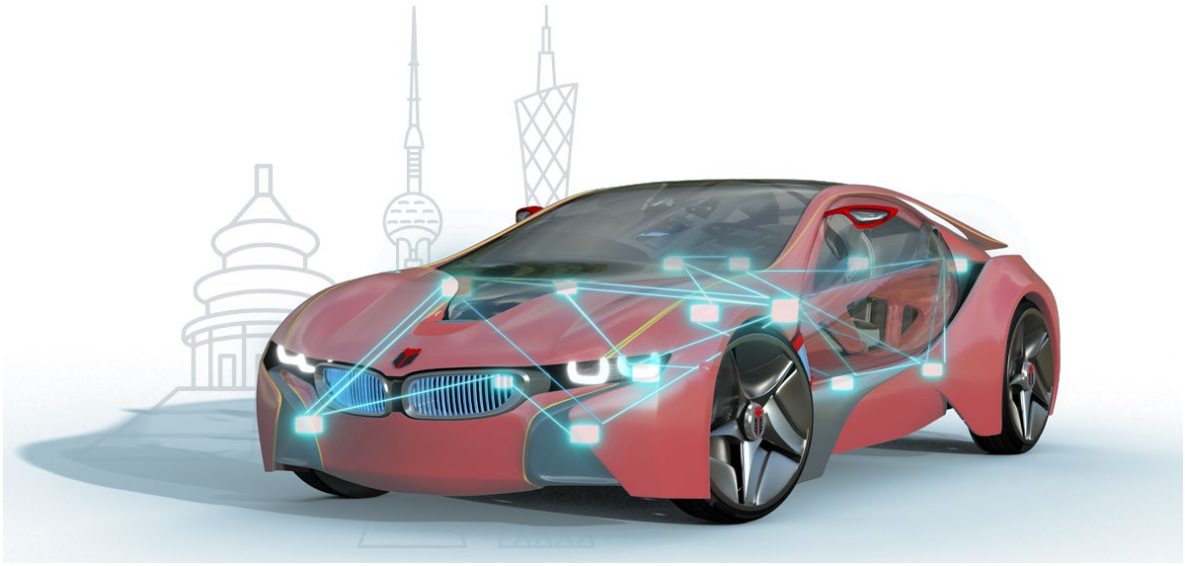
知从木牛 CryptoLibrary 瑞萨 RH850 U2A
产品手册
ZC.MuNiu CryptoLibrary Product Manual
Based On Renesas RH850 U2A

知从木牛基础软件平台信息安全库

ZC.MuNiu Basic Software Platform CryptoLibrary



知从木牛 CRYPTOLIBRARY 瑞萨 RH850 U2A 产品手册

ZC.MUNIU CRYPTOLIBRARY PRODUCT MANUAL BASED ON RENESAS RH850

知从木牛基础软件平台信息安全库

ZC.MuNiu Basic Software Platform CryptoLibrary

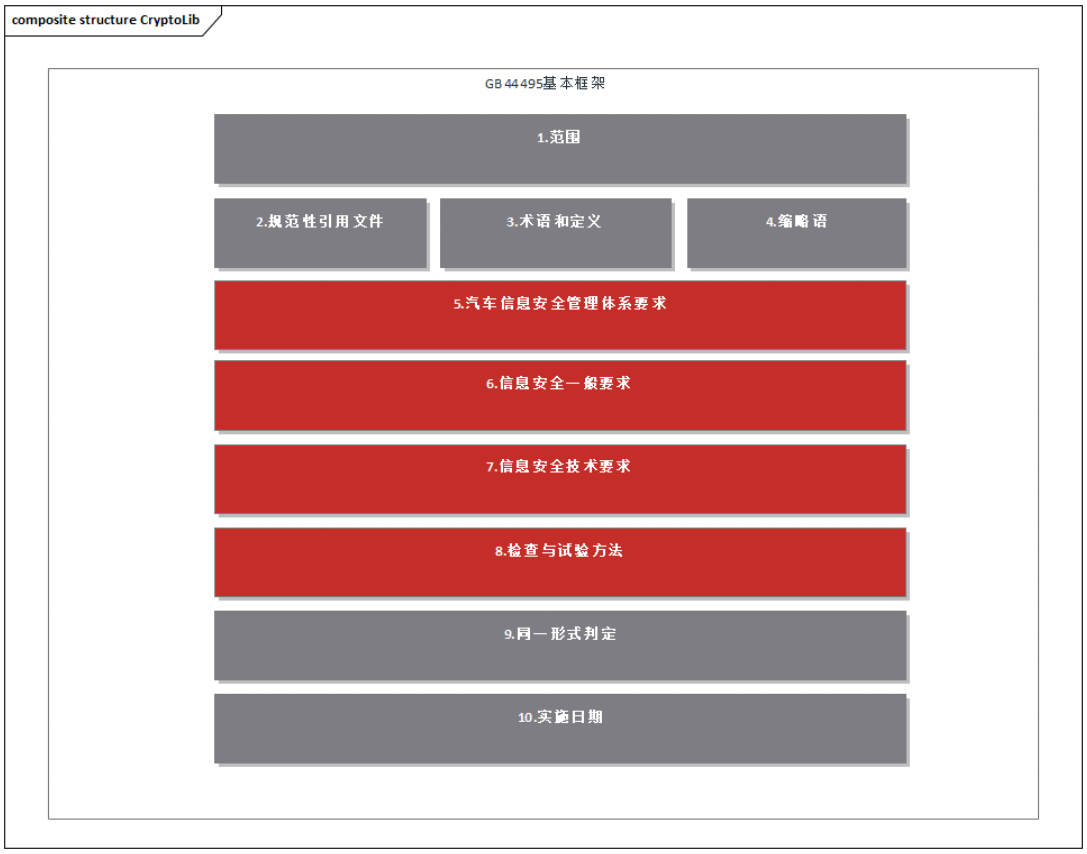
1 开发背景 DEVELOPMENT BACKGROUND

随着汽车电子技术的飞速发展，车辆已经从传统的机械设备转变为高度智能化、电子化和联网的复杂系统。这些技术的引入为驾驶者带来了极大的便利，但同时也带来了新的安全挑战。汽车的电子控制系统不仅要应对功能故障的威胁，还必须防范潜在的网络攻击，因此信息安全(Cybersecurity)和功能安全(FunctionalSafety）一样,已成为现代汽车设计中不可或缺的关键要素。为应对这一挑战，国际标准化组织（ISO）于 2021 年出台了 ISO 21434 标准，专门针对道路车辆的网络安全提供指导和框架。随着中国《汽车整车信息安全技术要求》标准于 2024 年下半年正式推出，进一步细化了汽车信息安全领域的技术规范与实施标准，并且标志着汽车安全领域将进入真正强监管时代。

With the rapid development of automotive electronics technology, vehicles have transformed from traditional mechanical devices into highly intelligent, electronic, and networked complex systems. The introduction of these technologies has brought great convenience to drivers, but at the same time, it has also presented new safety challenges. The electronic control systems of vehicles not only have to deal with the threat of functional failures but also must guard against potential cyberattacks. Therefore, Cybersecurity, like Functional Safety, has become an essential and crucial element in modern vehicle design.

To address this challenge, the International Organization for Standardization (ISO) introduced the ISO 21434 standard in 2021, which specifically provides guidance and a framework for the cybersecurity of road vehicles. With the official launch of the "Technical

Requirements for Vehicle Information Security" standard in China in the second half of 2024, the technical specifications and implementation standards in the field of automotive information security have been further refined, marking that the automotive safety field will enter an era of truly strict supervision.



GB 44495-2024 基本框架

GB 44495-2024 BASIC FRAMEWORK

2 产品概述 PRODUCT OVERVIEW

知从科技针对瑞萨 RH850 U2A 所开发的木牛 CryptoLibrary 包括硬件加密模块(ICUM)的内核固件(zICUM CORE)，主核的信息安全协议栈 CryptoStack（CSM、CRYIF、CRYPTO、KEYM）以及 ICUM CDD(zICUM COM、zICUM CRY)。内核固件除了满足 NIST 主流国际密码算法，如 AES、HASH、ECC 和 TRNG/DRNG 等，并且包含国密算法 SM2/3/4，还可扩展多种基于算法的功能：对称加解密、非对称签名生成与解签、安全启动、安全刷写和 SecOC 等。CryptoStack 和 ICUM CDD 除了满足支持 AUTOSAR 4.4.0 的版本需求外，还可以作为一个单独的复杂驱动，在非 AUTOSAR 环境集成。

ZC Technology has developed the MuNiu CryptoLibrary for Renesas RH850 U2A. It includes the kernel firmware (zICUM CORE) of the Hardware Encryption Module (ICUM), the Cybersecurity

Protocol Stack CryptoStack (CSM, CRYIF, CRYPTO, KEYM) of the main core, and ICUM CDD (zICUM COM, zICUM CRY). The kernel firmware not only meets the mainstream international cryptographic algorithms of NIST, such as AES, HASH, ECC and TRNG/DRNG, etc., but also contains the domestic cryptographic algorithms SM2/3/4. It can also extend a variety of algorithm-based functions: symmetric encryption and decryption, asymmetric signature generation and verification, secure boot, secure flashing and SecOC, etc. Besides meeting the version requirements supporting AUTOSAR 4.4.0, CryptoStack and ICUM CDD can also be used as a separate complex driver for integration in a non-AUTOSAR environment.

知从基于 RH850 U2A 提供的木牛 CryptoLibrary，添加了知从木牛加密协议栈（CryptoStack）包括：Csm 模块、CryIf 模块、Crypto 模块和 KeyM 模块，使其与 RH850 U2A 内核驱动适配。

ZC, based on RH850 U2A, provides the MuNiu CryptoLibrary and adds the ZC MuNiu Cybersecurity Protocol Stack (CryptoStack), which includes: Csm module, CryIf module, Crypto module and KeyM module, making it compatible with the RH850 U2A kernel driver.

- Csm 模块：位于服务层，用来处理用户信息安全任务配置管理与调度

  Csm module: Located at the service layer, it is used to handle the configuration management and scheduling of user information security tasks.

- CryIf 模块：位于 ECU 抽象层，用于实现 Csm 模块与 Crypto 模块之间的安全通信

  CryIf module: Located at the ECU abstract layer, it is used to achieve secure communication between the Csm module and the Crypto module.

- Crypto 模块：硬件抽象层，作用为实现 Host 端与 Icum 内核间数据传输，访问相关部件，实现加解密操作

  Crypto module: Located at the Hardware Abstract Layer, its function is to achieve data transfer between the Host side and the Icum kernel, access relevant components, and perform encryption and decryption operations.

- KeyM 模块：密钥管理与证书管理，用来实现密钥、证书与底层存储之间的交互

  KeyM module: Responsible for key management and certificate management, it is used to achieve the interaction between keys, certificates and the underlying storage.

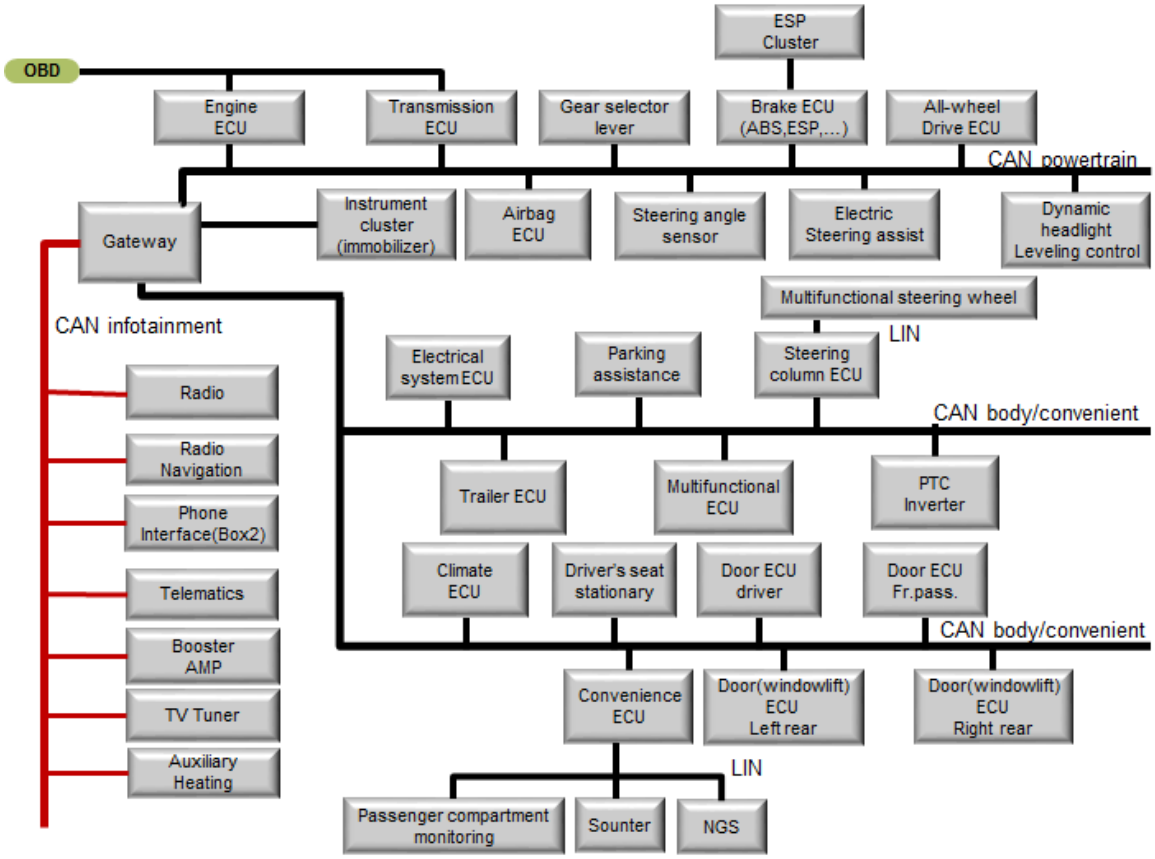
简而言之，木牛 CryptoLibrary 灵活地适用于瑞萨 RH850 U2A 产品，具有高扩展性，可以根据不同的客户项目要求进行升级配置和再开发，最终满足不同客户的信息安全需求。

In short, the MuNiu CryptoLibrary can be flexibly applied to Renesas RH850 U2A products and has high extensibility. It can be upgraded, configured and redeveloped according to the requirements of different customer projects, ultimately meeting the information security needs of different customers.

3 应用领域 APPLICATION FIELDS

木牛 CryptoLibrary 主要应用于有信息安全需求的控制器。本产品适应于汽车电子电气架构里的：动力域控制器，车身域控制器，安全域控制器和信息域控制器。

ZC.MuNiu CryptoLibrary is mainly applied to the controllers with Cybersecurity requirements. This product is suitable for the following components in the automotive electronic and electrical architecture: Powertrain Domain Controller, Body Domain Controller, Safety Domain Controller, and Information Domain Controller.



汽车电子电气架构

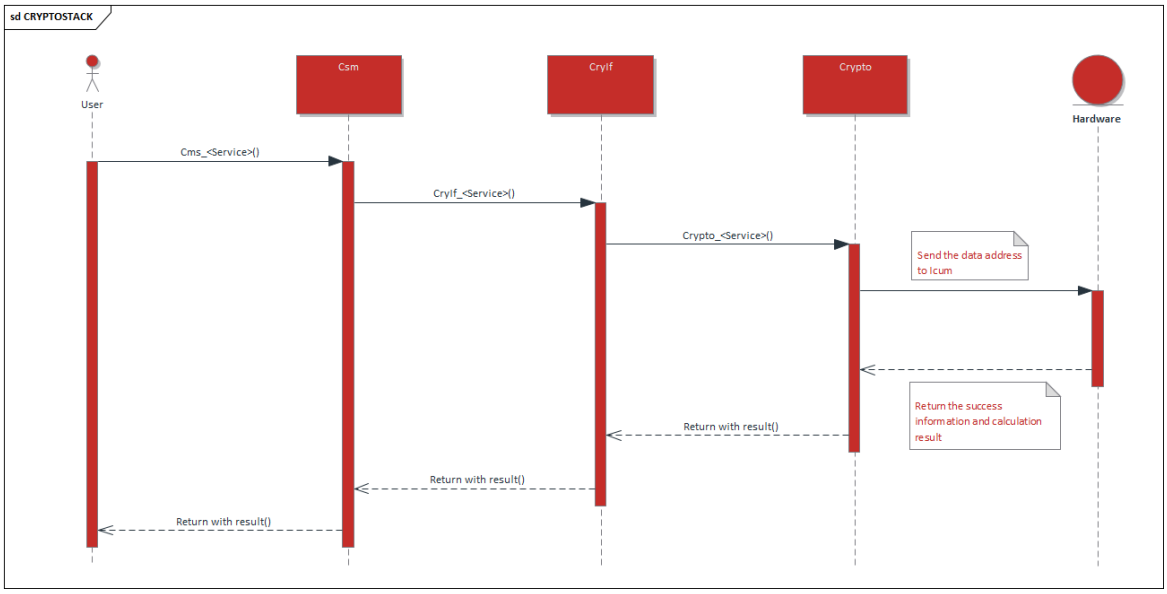
AUTOMOTIVE ELECTRONIC AND ELECTRICAL ARCHITECTURE

用户通过将木牛 CryptoLibrary 集成到基于 RH850 U2A 的汽车电控单元中，可以满足 AUTOSAR 标准里所规定的汽车电控单元所具有的信息安全功能。

By integrating ZC.MuNiu CryptoLibrary into the automotive electronic control unit based on RH850 U2A, users can meet the Cybersecurity functions required for automotive electronic control units as specified in the AUTOSAR standard.

4 功能描述 FUNCTIONAL DESCRIPTION

4.1 加密协议栈 Encryption Protocol Stack



CRYPTOSTACK 流程图

CRYPTOSTACK FLOWCHART

知从木牛加密协议栈主要由 Csm、CryIf、Crypto、KeyM 四个模块构成。Csm 模块通过配置 CsmJob 来实现用户所需的信息安全加密算法需求如 AES-128、CMAC、HASH、ECC、TRNG 等，并且提供接口供用户调用。CryIf 模块功能为连接服务层 Csm 模块与硬件抽象层 Crypto 模块，通过加密、解密、校验、认证等安全功能，保护数据的完整性和机密性。Crypto 模块实现 RH850 U2A 主核与 Icum 加密内核信息数据的传输。KeyM 模块实现密钥与证书的管理，包括对下载进 ECU 的密钥、证书解析校验，连接 ICMU 内核驱动将密钥存储进 ICMU 受保护区域等功能。

ZC.MuNiu Encryption Protocol Stack is mainly composed of four modules: Csm, CryIf, Crypto, and KeyM. The Csm module realizes users' Cybersecurity encryption algorithm requirements such as AES - 128, CMAC, HASH, ECC, TRNG, etc. by configuring CsmJob, and provides interfaces for users to call. The function of the CryIf module is to connect the service - layer Csm module and the hardware - abstraction - layer Crypto module. Through security functions such as encryption, decryption, verification, and authentication, it protects the integrity and confidentiality of data. The Crypto module realizes the transmission of information data between the main core of RH850 U2A and the Icum encryption kernel. The KeyM module realizes the management of keys and certificates. It includes functions such as parsing and verifying the keys and certificates downloaded into the ECU, and connecting to the ICMU kernel driver to store the keys in the protected area of the ICMU.

4.2 木牛 CryptoLibrary MuNiu CryptoLibrary of ZC

木牛 CryptoLibrary 的软件主要分为两部分:

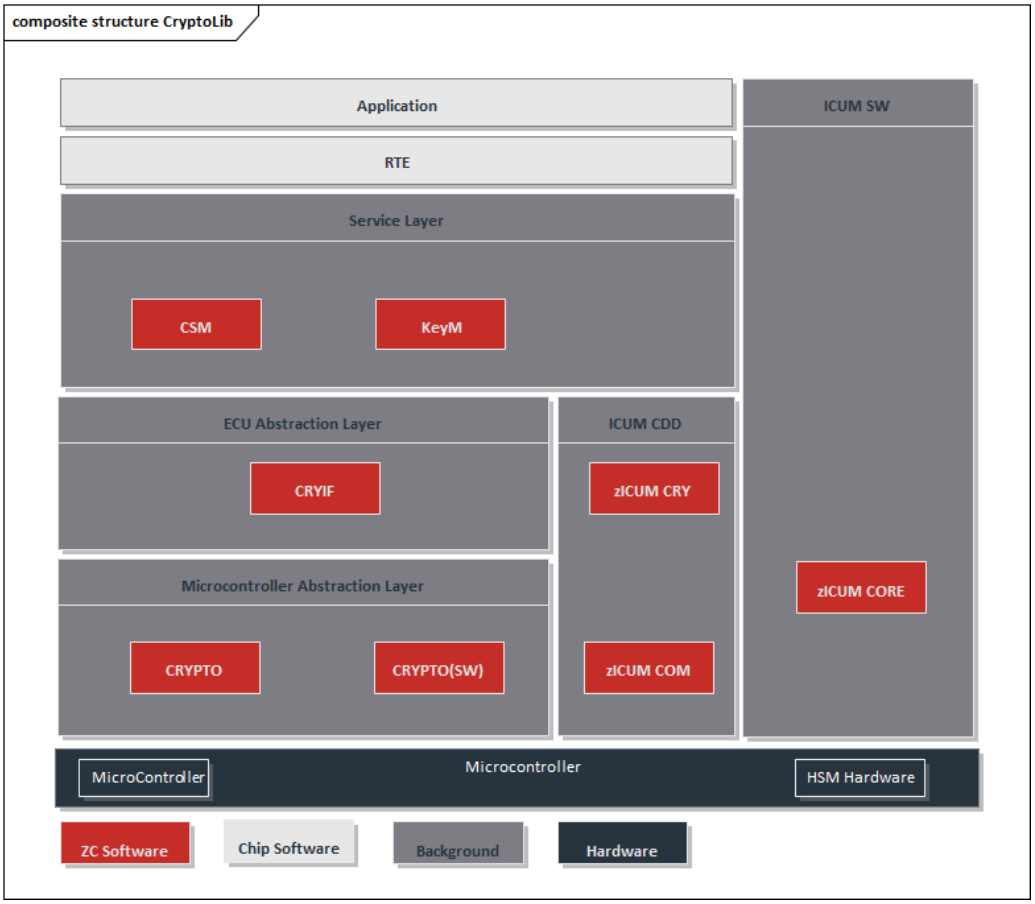
The software of ZC.MuNiu CryptoLibrary is mainly divided into two parts:

1)ICUM 硬件加密模块固件(zICUM CORE)

Firmware of ICUM Hardware Encryption Module (zICUM CORE)

2) RH850 G4MH 主核的 CryptoStack(CSM、CRYIF、CRYPTO、CRYPTO(SW))以及 ICUM CDD(zICUM COM、zICUM CRY)

CryptoStack (CSM, CRYIF, CRYPTO, CRYPTO(SW)) on the RH850 G4MH main core, and ICUM CDD (zICUM COM, zICUM CRY)



木牛 CRYPTOLIBRARY 的 AUTOSAR 集成

AUTOSAR INTEGRATION OF ZC.MUNIU CRYPTOLIBRARY

ICUM CDD 包含 Crypto 层调用接口 zICUM CRY 模块和 ICUM 通讯的 zICUM COM 模块两个子模块，各模块的功能介绍如表 1。

The ICUM CDD consists of two sub - modules: the zICUM CRY module which contains the call interface for the Crypto layer, and the zICUM COM module for ICUM communication. The functional descriptions of each module are shown in Table 1.

表 1 软件模块功能说明

Table 1 Functional Description of Software Modules

软件模块 Software Module	模块组件 Module Components	AUTOSAR Layer	功能定义 Functional Definition
zICUM CORE **(加密内核)** **(Encryption Kernel)**	zICUM CORE	N/A	使用了 ICUM 内部的硬件加速器，如随机数生成器、AES-128 等（如图 4） It uses the hardware accelerators inside the ICUM, such as the random number generator, AES - 128, etc. (as shown in Figure 4).
zICUM CDD **（主核）** **(Main Core)**	1) zICUM CRY 2) zICUM COM	CDD	微处理器 ICUM 驱动、与 ICUM 核的通信驱动、Crypto Interface 等 Microprocessor ICUM Driver, Communication Driver with ICUM Core, Crypto Interface, etc.
CRYPTOSTACK **（主核）** **(Main Core)**	1) CSM 2) CRYIF 3) CRYPTO KEYM	SERVICE ECU ABSTRACTION MICROCONTROLLER ABSTRACTION	用户信息安全密钥和 JOB 管理的接口函数，用于配置信息 Interface functions for user information security key and JOB management, which are used for configuration information.

木牛 CryptoLibrary 也支持 SHE 标准，和标准的 SHE 相比，CryptoLibrary 在功能上有一些扩展，包括软件或硬件算法支持，主要功能及区别见表 2 和 3。

The ZC.MuNiu CryptoLibrary also supports the SHE standard. Compared with the standard SHE, the CryptoLibrary has some functional expansions, including support for software or hardware algorithms. The main functions and differences are shown in Table 2 and Table 3.

表 2 木牛 CryptoLibrary 的主要功能

Table 2 Main Functions of ZC.MuNiu CryptoLibrary

Features		SHE standard	木牛 CryptoLibrary MuNiu CryptoLibrary
AES 128 密码模式 AES 128 Cipher Modes	ECB	✓	✓
	CBC	✓	✓
	CFB	✓	✓
	OFB	✓	✓
	XTS	✓	✓
AES 128 消息认证码 AES 128 Message Authentication Code	CMAC	✓	✓
随机数生成器 Random Number Generator	伪随机数 Pseudorandom number	✓	✓
	硬件随机数 Hardware random number	／	✓

Features		SHE standard	木牛 CryptoLibrary MuNiu CryptoLibrary
安全启动 Secure Boot		✓	✓
非易失性密码槽 Non - Volatile Cryptographic Slot		10	>50
可易失性密码槽 Volatile Cryptographic Slot		✓	✓
支持可用于 UDS0x29 认证密钥 Support authentication keys that can be used for UDS0x29.		／	✓
安全诊断 UDS 0x29 认证 Security diagnostic UDS 0x29 authentication		／	✓
非对称加密 Asymmetric Encryption	ECC	／	✓
	RSA	／	✓
	Ed25519	／	✓
密钥协商 Key Negotiation	ECDH	✓	✓
	X25519	／	✓
	KDF	✓	✓
密钥存储 Key Storage	RSA 密钥生成 RSA Key Generation	／	✓

Features		SHE standard	木牛 CryptoLibrary MuNiu CryptoLibrary
	RSA 密钥存储 RSA Key Storage	／	✓
	ECC 密钥生成 ECC Key Generation	／	✓
	ECC 密钥存储 ECC Key Storage	／	✓
	Custom Externsion 支持 Custom Extension Support	／	✓
国密算法 National Cryptographic Algorithm	SM2	／	✓
	SM3	／	✓
	SM4	／	✓

表 3 木牛 CryptoLibrary 的 SHE 功能说明

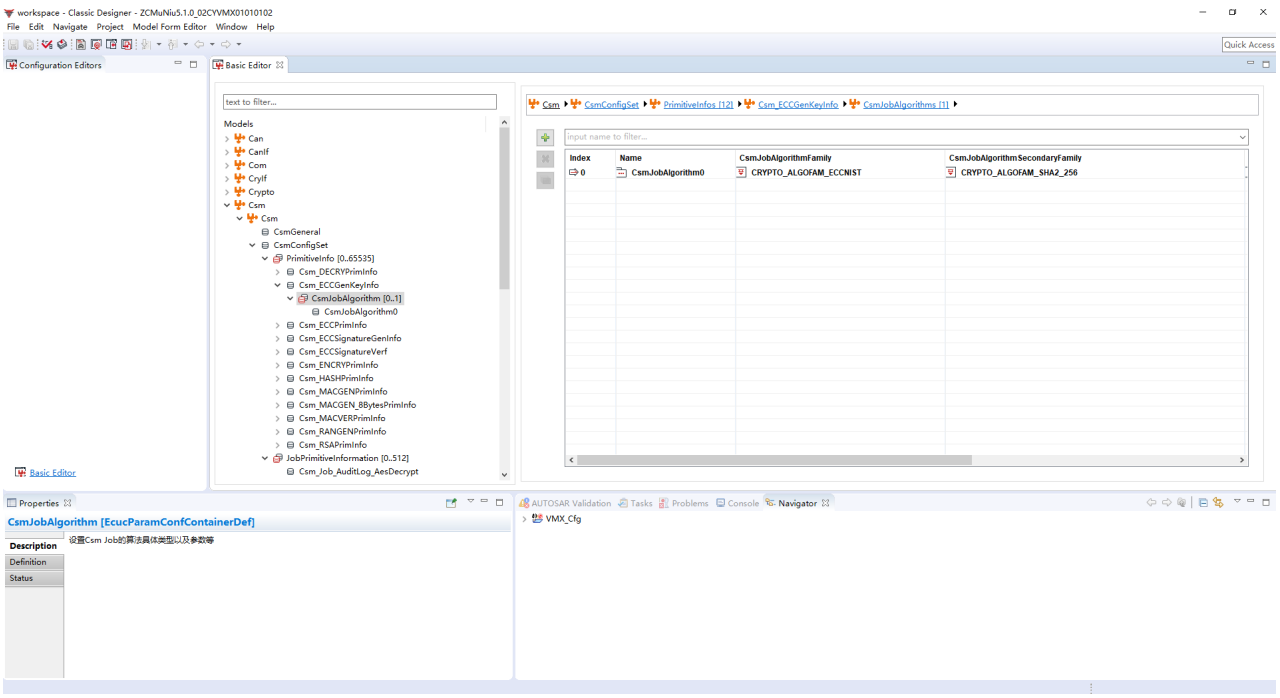
Table 3. Mu Niu CryptoLibrary's SHE Function Description

主要功能 Main Functions	解释说明 Explanation and Illustration
SHE 对称密钥加解密 SHE Symmetric - Key Encryption and Decryption	对称式 AES-128，支持 ECB 和 CBC 加密模式对称加密 Symmetric AES - 128, supporting symmetric encryption in ECB and CBC encryption modes

主要功能 Main Functions	解释说明 Explanation and Illustration
SHE CMAC 消息认证码生成与校验 **SHE CMAC Message Authentication Code Generation and Verification**	对称式 AES-128 消息认证码 Symmetric AES - 128 Message Authentication Code
SHE CMAC 安全消息认证码生成与校验 **Generation and Verification of SHE CMAC Secure Message Authentication Code**	支持安全 CMAC 验证，使应用程序能够检查安全相关数据的完整性 Supports secure CMAC verification, enabling applications to check the integrity of security - related data.
SHE 明文密钥装载 **SHE Plaintext Key Loading**	存储 128 位密钥到 ICUM 的 RAM, 不涉及安全协议 Store the 128 - bit key into the RAM of ICUM, without involving security protocols.
SHE 密钥导出 **SHE Key Derivation**	对导出 RAM 密钥进行包装(加密和身份验证) Wrap (encrypt and authenticate) the key exported from the RAM.
SHE 基于安全协议的密钥装载	使用安全协议将 128 位密钥存储在 ICUM 非易失性存储器中 Store the 128 - bit key in the non - volatile memory of ICUM using a security protocol.
SHE 随机数生成 **SHE Random Number Generation**	使用 AES 生成伪随机数,种子由 TRNG 生成 Generate pseudo - random numbers using AES, with the seed generated by TRNG.
SHE 安全启动 **SHE Secure Boot**	验证应用程序启动代码的 CMAC. Verify the CMAC of the application startup code.
SHE 调试模式 **SHE Debug Mode**	使用安全协议启用对 ICUM 调试接口的访问 Enable access to the ICUM debug interface using a security protocol.
SHE 状态获取 **SHE Status Retrieval**	获取 SHE 状态. Obtain the SHE status.
SHE 命令取消	取消当前正在执行的操作.

主要功能 Main Functions	解释说明 Explanation and Illustration
SHE Command Cancellation	Cancel the currently executing operation.
SHE 错误报告 **SHE Error Reporting**	除了 CSM 返回代码之外，还可以通过 AUTOSAR 机制报告 SHE 错误 Besides the CSM return code, SHE errors can also be reported through the AUTOSAR mechanism.
SHE 超时处理 **SHE Timeout Handling**	如果 ICUM 响应时间超过预定义的限制，则报告错误 If the ICUM response time exceeds the predefined limit, an error is reported.
应软件更新支持 **Software update support should be provided (Cipher 和 MAC)**	在应用软件的更新过程中也可以使用密码和 MAC 功能 Cryptography and MAC functions can also be used during the update process of the application software.
硬件随机数 **Hardware Random Numbers**	支持生成真随机数 Supports the generation of true random numbers.
AES 加密扩展 **AES Encryption Modes (OFB, CFB, CTR, XTS,GCM)**	支持额外的 AES 模式 Supports additional AES modes.
密钥扩展 **Key Expansion**	支持扩展更多的非易失性密钥 Supports the expansion of more non - volatile keys.

4.3 配置工具 Configuration Tools



知从木牛 CRYPTOSTACK 配置界面图

CONFIGURATION INTERFACE DIAGRAM OF ZHICONG MUNIU CRYPTOSTACK

为了满足客户的不同项目需求，提高木牛 CryptoLibrary 的扩展性，瑞萨 RH850 U2A 实现了各个模块可配置性，并且实现了木牛 CryptoLibrary 的配置工具。客户可根据不同需求，在配置工具上完成 Safety Library 各个模块的配置工作，可生成配置代码文件，将生成的配置文件集成到工程中即可。

To meet the diverse project requirements of customers and enhance the expandability of the Muniu CryptoLibrary, Renesas RH850 U2A has achieved the configurability of each module and developed a configuration tool for the Muniu CryptoLibrary. Customers can, according to their different needs, complete the configuration of various modules of the Safety Library on this configuration tool. It is capable of generating configuration code files, which can be integrated into the project.

配置环境 Configuration Environment	
Hardware (Chip)	RH850 U2A
Compilers Supported	Green Hills MULTI v7.1.6
Evaluation Hardware	RH850 U2A R7F702300 EABA-C
Debugger	Lauterbach (TRACE32 2023/02) Isystem (IC5700)
Configuration Tools	Muniu_v5.0.5
Configuration Environment	Win10 64bit

Green Hills 编译器选项 Green Hills Compiler Options	
Green Hills 编译选项 Green Hills Compilation Options	-mcpu=RH850-U2A -c –Os -ggdb3 -mcpu= RH850-U2A -mthumb -mlittle-endian -fomit-frame-pointer -msoft-float -fno-common -Wall -Wextra -Wstrict-prototypes -Wno-sign-compare -fstack-usage -fdump-ipa-all -std=c99
Green Hills 链接选项 Green Hills Linking Options	-mcpu= RH850-U2A -msoft-float -mthumb -e _start -nostartfiles -static -lc -lm -lgcc -lnosys

6 证书 CERTIFICATES

中华人民共和国国家版权局
计算机软件著作权登记证书

证书号： 软著登字第14036127号

软 件 名 称： 知从木牛信息安全软件
[简称：知从木牛]
V4.1.0

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： 2024SR1632254

根据《计算机软件保护条例》和《计算机软件著作权登记办法》的规定，经中国版权保护中心审核，对以上事项予以登记。

中华人民共和国国家版权局 计算机软件著作权登记专用章

2024年10月29日

木牛软件著作权登记证书

CERTIFICATE OF REGISTRATION OF MUNIU SOFTWARE COPYRIGHT

上海市软件行业协会

软件产品证书

经评估,知从木牛信息安全库软件[简称：信息安全库]V1.0 符合《进一步鼓励软件产业和集成电路产业发展的若干政策》和《软件产品评估规范》的有关规定，评估为软件产品，特发此证。

申请企业：上海知从科技有限公司
软件类别：应用软件
证书编号：沪ZC-2021-0019
有 效 期：五年

上海市计算机软件评测重点实验室
（上海计算机软件技术开发中心）
二〇二一 年 一 月二十五 日

木牛软件产品登记证书

CERTIFICATE OF REGISTRATION OF MU NIU SOFTWARE PRODUCT