Application Report

Wi-SUN® Software Product Brief v.1.0.0

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ABSTRACT

This Wi-SUN® Software Product Brief describes the overall Wi-SUN® software content and supporting ecosystem from Texas Instruments. The document provides a high level overview of the features and capabilities of the Wi-SUN® software without specific details. For further information on APIs and implementation details, please see the Wi-SUN® Developers Guide inside the simplelink_cc13x2_26x2_sdk_5_20 SDK available here: www.ti.com/tool/SIMPLELINK-CC13X2-26X2-SDK

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Trademarks

Acronyms

The following is a list of acronyms that appear in this application report:

- PKI - public key infrastructure
- CA- certificate authority
- PMK - pairwise master key
- PTK - pairwise transient key
- GTK - group transient key
- NWP - network processor

1 Overview

Wi-SUN® is a standards-based mesh network with frequency hopping. The Wi-SUN® Alliance has more than 300 members from 46 countries, with 100M+ devices deployed world-wide. Wi-SUN® supports IPv6 protocol suite and standards based multi-layer security. The standard supports multiple data rates and frequency bands to meet different regulatory requirements world-wide. Applications include smart grid and smart city applications, with certified products enabling multi-vendor interoperability.

TI's Wi-SUN® FAN v1.0.0 solution is based on the open source IETF RFC components integrated on top of Wi-SUN® compliant TI 15.4 Stack. A Network Interface Model is provided based on an open-source SPINEL interface. In typical applications, customers develop their application on top of IPv6 using UDP as the transport layer.

TI's Wi-SUN® FAN v1.0.0 solution is optimized for small memory footprint to fit embedded devices, in addition to optimizations for lower power. Integration and testing of the software stack is done in tagged, certified releases.

Table 1-1. Software Overview

Component	Version
TI Wi-SUN® release	v1.0.0
Distribution	Included in SDK5.20 for CC13x2 and CC26x2 devices as library code
IDE support	CCS v 10.3 for Windows® 10, Linux®, and macOS®
Compiler support	TI Clang 1.2.1
RTOS support	TI-RTOS
Supported devices	Border router: CC1312R7, CC1352P7 (704KB FLASH devices) Routers and nodes: CC1312R, CC1352R, CC1352P, CC1312R7, CC1352P7
Recommended development kits	Border router: PC (host) + CC1352P7 LaunchPad™ Routers and nodes: CC1352P LaunchPad™
Certifications	Wi-SUN® FAN 1.0 router on CC13x2R/P Wi-SUN® FAN 1.0 router on CC13x2R7/P7 Wi-SUN® FAN 1.0 border router under certification

2 Reference Examples

Table 2-1. Code Examples Included

Application	Usage
Python interface module for NWP	Reference code to control a NWP from a Linux or Windows® 10 PC. Public on TI GitHub
Border router in NWP configuration	Border router controlled over UART with TI defined API (based on SPINEL interface layer).
Router in NWP configuration	Router controlled over UART with TI defined API (based on SPINEL interface layer).
Embedded router example	Single chip router example with embedded CoAP server

Table 2-2. Available Memory with Reference Examples Running on Select TI Devices

Code Example and Wireless MCU	Available FLASH	Available RAM	Comments
NWP border router on CC1312R7 or CC1352P7	314KB	26KB	User not expected to add code to NWP image. Only board level configuration done by user.
NWP router on CC1312R or CC1352P	30KB (1)	10KB (1)	
Embedded router on CC1312R7 or CC1352P7 (CoAP based)	376KB	74KB	—

(1) Expected available FLASH and RAM in future release

3 RF Protocols

3.1 Wi-SUN® PHYs

Wi-SUN® supports a number of frequencies and data rates to enable world-wide coverage and address different application needs. Major frequency bands used are 902 to 928 MHz for North America, 863 to 876 MHz for Europe and 920 to 928 MHz for Japan. Further details and information about frequency plan and channels is available to Wi-SUN® alliance members.

Table 3-1. Wi-SUN® PHYs and TI Support Overview

Symbol Rate (ksymbol/s)	Modulation Index	Wi-SUN® Mode	Frequency Bands	Regulatory Compliance Targets	Mandatory Wi-SUN® FAN 1.0 PHY	Support
50	0.5	#1a	EU	EN300 220	Yes	Yes
	1.0	#1b	NA	FCC 15.247	Yes	Yes
100	0.5	#2a	EU and NA	EN300 220 FCC 15.247	Yes	Yes
	1.0	#2b	JP	ARIB STD-108	No	Yes
150	0.5	#3	NA and JP	FCC 15.247 ARIB STD-T108	Yes	Yes
200	0.5	#4a	NA	FCC15.247	No	Yes
	1.0	#4b	JP	ARIB STD-T108	No	Yes
300	0.5	#5	NA and JP	FCC15.247 ARIB STD-T108	No	No (Coming later)

4 Software Block Diagram

Table 4-1. Overview of Software Layers and TI Implementation

Layer	Wi-SUN® FAN	TI Router and Border Router
NWP	Not Defined	Based on open source SPINEL interface.
Security	EAP-TLS, 802.11i, 802.1X	Based on open source components.
Transport Layer	UDP	
Network Layer	IPv6	
	ICMPv6	
	RPL	
	6LoWPAN	
Data Link Layer	Frequency hopping MAC	Based on TI 15.4 Stack.
PHY Layer	IEEE 802.15.4g	Based on TI 15.4 Stack.

5 Network Topology and Features

TI's Wi-SUN® FAN v1.0.0 solution supports the following device types and solutions:

- Border router
  - Based on TI CC13x2x7 series (704 KB) memory devices in Network Processor (NWP) mode requiring a Host Processor for providing back bone connectivity
  - Supports UART communication through a TI defined NWP interface (based on SPINEL interface layer)
- Router device in NWP model
  - Supported in both TI C13x2xx series (352 KB) and CC13x2x7 series (704 KB) devices
  - Supports UART communication through a TI defined NWP interface (based on SPINEL interface layer)
- Embedded Router
  - Based on TI CC13x2x7 series (704KB) memory devices
  - Provides an example implementation based on CoAP Application

The following network features are available in this release:

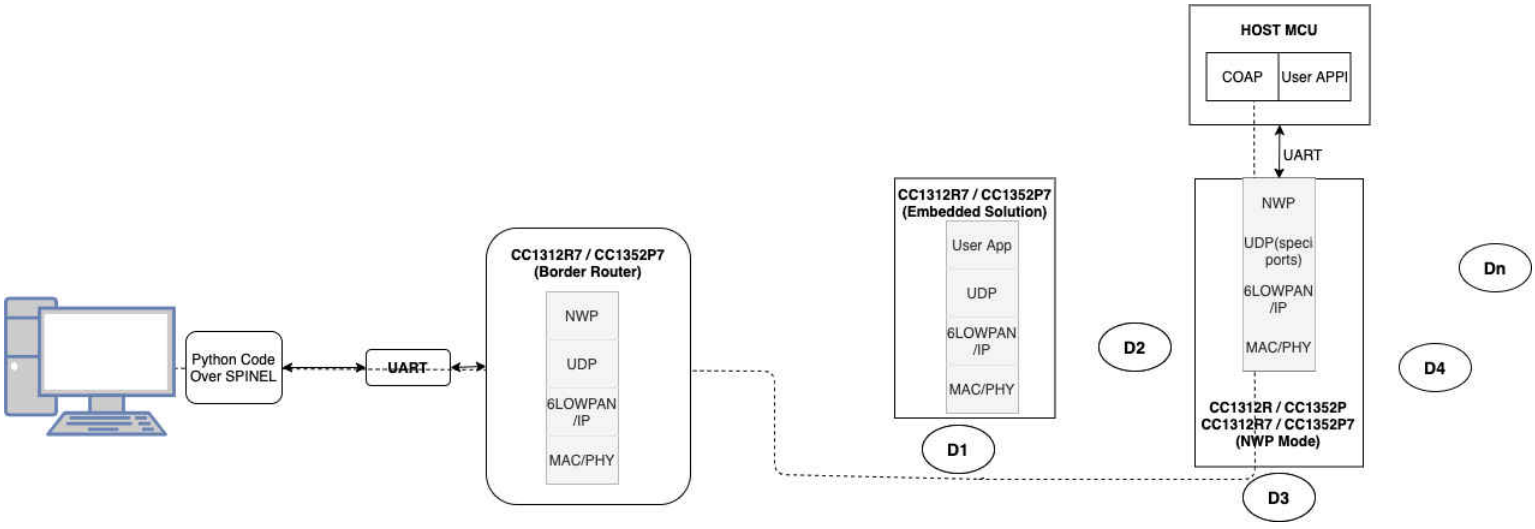

Figure 5-1. Mesh Network with Border Router and Routers (D1, D2...Dn) Using NWP Implementation

Supported Traffic Type:

- TI's Wi-SUN® FAN v1.0.0 solution supports UDP over a IPv6 network

6 Security

TI's Wi-SUN® FAN v1.0.0 solution supports best in class network security based on IEEE 802.1x specification:

Table 6-1. Security Enablers in TI Wi-SUN® FAN v1.0.0

Category	Security Enabler
Wi-SUN® FAN v1.0.0 security specification	IEEE 802.11i key WAN Management
	IEEE 802.1x for authentication and encryption
	AES-128 encryption
	ECC based key exchange and signature verification
	True random number generation for security protocols
	IEEE802.1AR defined X.509 certificates

Figure 6-1 summarizes key aspect of the key exchange mechanism:

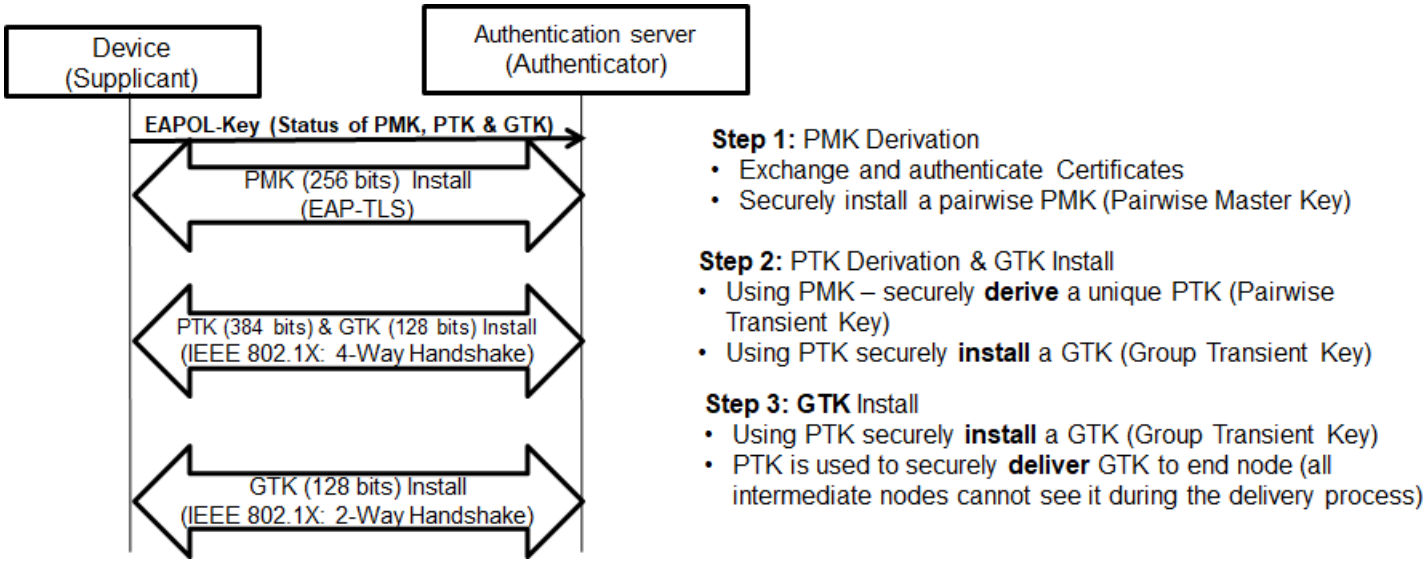

Figure 6-1. Security Key Exchange Mechanism in Wi-SUN®

6.1 Certificate Management

Each device is recommended to have its own unique certificate. Customer can either use their own PKI infrastructure or work with Global Sign (a Wi-SUN® Alliance Partner - wi-sun.org/cyber-security-certificates).

6.2 Key Exchange Process

The following list is an overview of the security key exchange process:

- A unique Pairwise Master Key (PMK) and Pairwise Transient Key (PTK) is established between Device and Border Router
- PTK is used to securely install a GTK (Group Transient Key) to individual devices
- GTK is used by devices to encrypt MAC payload packets using AES-128 CCM* as defined in IEEE 802.15.4
- It is up to network management to define the life time for the different keys and perform key management
- Typically, lifetime of PMK, PTK , and GTK are in descending order (default value: 4, 2 and 1 month respectively)

This stack release supports default certificates (compiled into code for field trials).

7 Performance and Test Data

Test data for this revision includes a 25 node mesh network with a 4 hop network topology. Border router will "ping" each device periodically one by one. Ping packet size is 50 bytes; ping interval is 5 seconds. Test is run for 24 hours.

Table 7-1. 25-node Mesh Network Test Data

Test Parameter	Result
End-to-end delay (1)	Hop 1: 218ms Hop 2: 329ms Hop 3: 458ms Hop 4: 605ms Overall average: 366ms
Average packet error rate (PER) (1)	1.3%
Average network join delay (1)	20 minutes

(1) Measured on 25-node test network over 24 hours. An out-of-the-box 2- to 3-node network will join in 3 to 5 minutes.

Table 7-2. TI Wi-SUN® FAN 1.0 Performance Data

Performance Data	Result
Maximum network hops	Wi-SUN® FAN 1.0 standard supports up to 24 hops
Maximum network size	Network size is limited by border router's RAM, in addition to application use-case details. TI recommends using up to approximately 300 nodes per border router recommended for 144KB RAM device. Multiple border routers can be used to scale the network. TI devices with larger memory can support larger networks.
PHY certification results	Wi-SUN® FAN 1.0 PHY for: • US and BZ regions • EU1, EU2, IN, and SG regions
FAN certification results	Wi-SUN® FAN 1.0 certified router stack

8 Out-of-box Experience

This stack release is intended for initial development of a Wi-SUN® network. The following out-of-box experience is provided:

- Border router can be setup using PCs communicating with a NWP border router over a CC1352P7 series device (a reference implementation is provided)
- Router nodes (even in a NWP model) can be compiled as a self contained solution that can join a network when powered on and respond to an IPv6 ping
- Field testing can be performed by pinging individual devices without building a customer application
- Customer applications can be built on a separate host and communicate with a router over a NWP interface using UART
- An embedded router node example based on CC1312R7 and CC1352P7 series devices shows how a simple CoAP server can be hosted over a router device
- Reference Python scripts provides examples on interacting with out-of-box CoAP server resources
- Customers can develop single-chip custom applications over Wi-SUN® stack using the embedded router node example as reference

Start by going to the CC1352P7 Product Folder.

9 Tools

9.1 Code Composer Studio

Latest release per July 2021 is v10.3.1. Link to Code Composer: www.ti.com/tool/CCSTUDIO

9.2 SysConfig

The SysConfig Utility is a software tool which provides a Graphical User Interface for configuring pins, peripherals, radios, subsystems, and other components for TI devices. Results output as C header and code files that can be imported into software development kits (SDKs) or used to configure custom software.

9.3 Packet Sniffer

Latest release per Feb 2021 is v1.9.0. Link to Packet Sniffer: www.ti.com/tool/PACKET-SNIFFER

- Wi-SUN® PHY modes supported: #1a, #1b, #2a, #2b, #3, #4a, and #4b
- Packet sniffer is single channel only, but multiple boards can be used to sniff multiple channels

9.4 TI Wi-SUN® FAN Spinel

The TI Wi-SUN® FAN Spinel CLI exposes the configuration and management APIs running on a TI Wi-SUN® FAN Network Processor (NWP) via a command line interface. This tool is primarily suitable for manual experimentation with controlling TI Wi-SUN® FAN NWP instances and is not meant for expanding into production grade driver software for TI Wi-SUN® FAN NWP devices.

This tool will be helpful for the following purposes:

1. As a path for automated testing and performing field trials with TI Wi-SUN® FAN NWP running on TI SimpleLink™ devices.
2. As a simple debugging tool for NWP builds of TI Wi-SUN® FAN stack.

Public on TI GitHub.

10 Known Limitations

This version is tested with a 25-node network.

11 Software Product Roadmap

Table 11-1. Planned TI Wi-SUN® Releases

Version	Features
v1.0.1	Wi-SUN® FAN 1.0 border router certification Border router application with web interface Large node network test data (100 nodes)
Future	Wi-SUN® FAN 1.1 compliance and certification.

12 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
July 2021	*	Initial Release

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