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NRC7394 Application Note

(Standalone Relay)

Ultra-low power & Long-range Wi-Fi

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NEWRACOM, Inc.

Application Note (Standalone Relay)
Ultra-low power & Long-range Wi-Fi

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1 Introduction

The NRC7394 HaLow standalone mode provides two wireless interfaces, namely wlan0 and wlan1. Since the chipset supports a single radio, both interfaces operate on the same radio frequency. Although both wlan0 and wlan1 can be configured as either an AP (Access Point) or an STA (Station), this document assumes that wlan0 operates as an AP interface while wlan1 functions as a station interface.

To configure the device as a HaLow relay, both wlan0 and wlan1 must be initialized simultaneously, followed by the creation of a network bridge interface that includes both interfaces.

While alternative network configurations, such as Network Address Translation (NAT), can be used to establish communication between wlan0 and wlan1, this document focuses on a bridged network configuration for relay operation.

2 Network Setup Description

In a relay configuration, wlan0 operates as an AP to extend HaLow network coverage by allowing additional stations to associate.

The wlan1 interface, configured as a station, connects to a parent AP and provides seamless network connectivity to downstream end-station devices.

Figure 1 illustrates the overall network topology.

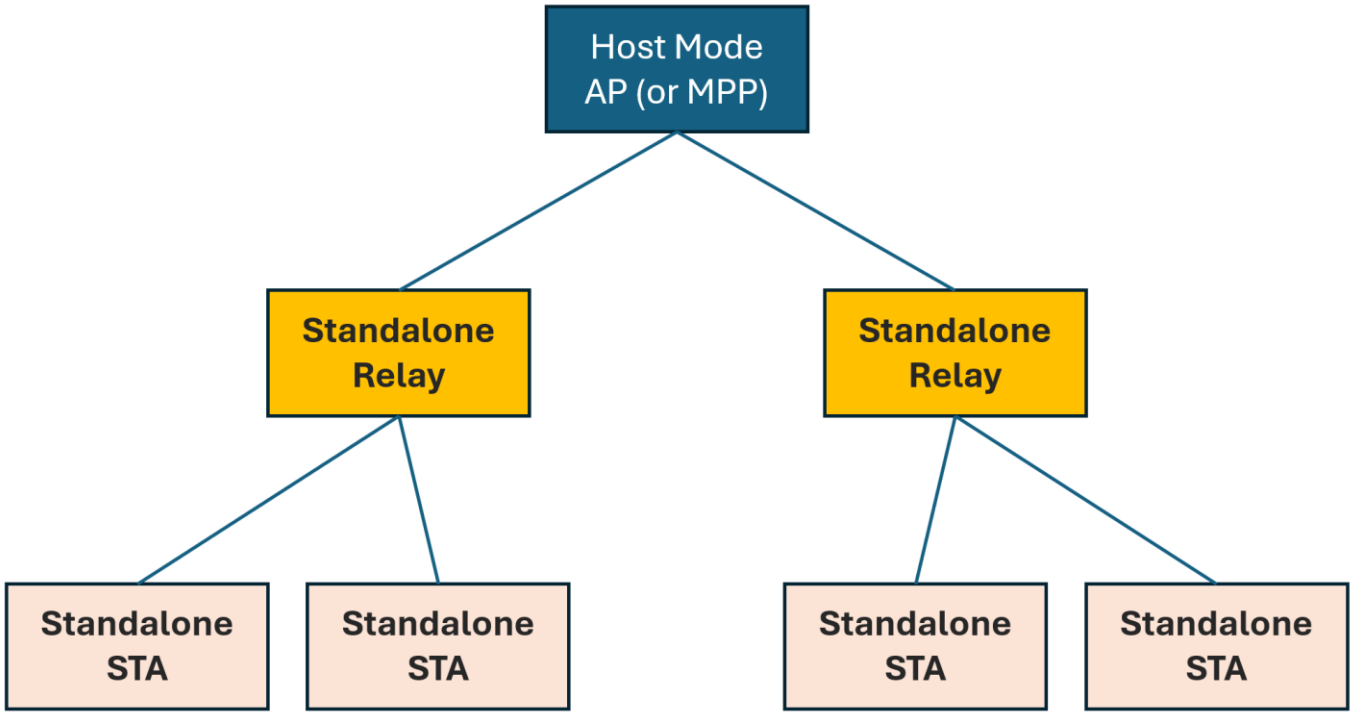

Figure 2.1 Standalone Relay Topology

3 Setting Up the Parent AP

This document assumes that the user is operating the AP in Host mode over the SPI interface.

For initial setup and instructions on starting the Host mode AP, refer to the following document:

UG-7394-001-EVK User Guide (Host Mode).pdf
https://github.com/newracom/nrc7394_sw_pkg/blob/master/package/doc/UG-7394-001-EVK%20User%20Guide%20(Host%20Mode).pdf

To enable communication between the NRC HaLow standalone relay and the parent AP, WDS (Wireless Distribution System) must be enabled on the parent AP.

When a bridge interface is configured for relay operation, the underlying system automatically enables WDS. This is required to support seamless end-to-end communication between the parent AP and downstream end-station devices.

This section assumes that the user is already familiar with the Python startup script (start.py) used to launch the AP, as described in the Host mode user guide. The configuration must now be modified as described below.

First, install the bridge-utils package on the Raspberry Pi Debian OS:

```
sudo apt install bridge-utils
```

This package is required to allow the startup script to configure WDS operation correctly.
The hostapd configuration file is located at:

```
nrc_pkg/script/conf/<country>/ap_halow_<security>.conf
```

For example, if the country code is US and WPA3-SAE is selected as the wireless security mode, modify the following file:

```
nrc_pkg/script/conf/US/ap_halow_sae.conf
```

Within the configuration file, the following parameters are commented out by default:

```
#wds_sta=1
#bridge=br0
```

Uncomment both lines as shown below:

```
wds_sta=1
bridge=br0
```

In this case, hostapd should be launched directly.

Alternatively, the same configuration can be achieved by enabling the bridge-related parameters in the start.py script.

```
use_bridge_setup  = 2
bridge_ip_mode = 2
```

The **use_bridge_setup** parameter specifies the index of the Ethernet interface to be added for bridge interface. The value corresponds to eth(n-1), where n represents the parameter value. For example, to use eth1 as the bridge interface, set use_bridge_setup=2.

The **bridge_ip_mode** parameter controls the IP configuration method for the bridge interface.
A value of 0 selects a static IP configuration, 1 configures the AP as a DHCP client, and 2 configures the AP as a DHCP server.

Accordingly, the example above configures br0 as a bridge interface that includes wlan0 and eth1, with the AP operating as a DHCP server.

And then start the AP by executing the following command from the /home/pi/nrc_pkg/script directory:

```
./start.py 1 3 US
```

Upon successful startup, the AP operates with WDS enabled.

As stations associate with the AP, hostapd dynamically creates virtual interfaces (for example, wlan0.sta1, wlan0.sta2, and so on). Each virtual interface is automatically added to the bridge interface managed by hostapd.

4 Relay Configuration Steps

The standalone NRC7394 device can be configured to operate as a relay through the console interface. The wpa and wpb commands are used to control wlan0 and wlan1, respectively.

The following steps describe how to configure wlan0 as a SoftAP and wlan1 as a station interface, and then bridge the two interfaces.

4.1 SoftAP Configuration

Collectively, these commands configure and enable a Wi-Fi network using wpa, setting up the device to operate as an AP with the specified security and operational parameters.

	Commands	**Description**
1	wpa set country US	Sets the regulatory domain to the United States, which ensures that the Wi-Fi operates within the legal frequency ranges and power limits for the US.
2	wpa add_network	Adds a new network configuration block in the wpa_supplicant configuration. This creates a new network entry with an identifier, typically starting from 0.
3	wpa set_network 0 ssid "halow_demo_relay_ap"	Sets the SSID (Service Set Identifier) for network 0 to "halow_demo_relay_ap". This is the name of the Wi-Fi network that will be broadcasted.
4	wpa set_network 0 pairwise CCMP	Sets the pairwise cipher suite to CCMP (Counter Mode with Cipher Block Chaining Message Authentication Code Protocol) for network 0. CCMP is an encryption protocol used in WPA3.
5	wpa set_network 0 group CCMP	Sets the group cipher suite to CCMP for network 0. This is used for broadcast and multicast traffic encryption.
6	wpa set_network 0 key_mgmt SAE	Sets the key management protocol to WPA3-SAE for network 0.
7	wpa set_network 0 proto RSN	Sets the protocol to RSN (Robust Security Network) for network 0. RSN is another name for WPA2/WPA3, which provides stronger security than WPA.
8	wpa set_network 0 ieee80211w 2	Enables IEEE 802.11w (Protected Management Frames) for network 0. This setting protects management frames.

9	wpa set_network 0 frequency 5805	Sets the operating frequency for network 0 to 5805 MHz. This specifies the Wi-Fi channel to be used and should match the channel of the parent AP. (Note: The frequency will be internally converted to sub-1 GHz for Halow.)
10	wpa set_network 0 scan_freq 5805	Sets the scan frequency to 5805 MHz for network 0. This restricts scanning to the specified frequency, speeding up the connection process.
11	wpa set_network 0 mode 2	Sets the mode for network 0 to 2, which configures the interface to operate as an AP
12	wpa set_network 0 beacon_int 1000	Sets the beacon interval for network 0 to 1000 milliseconds. This is the time interval between successive beacons sent by the AP.
13	wpa set_network 0 sae_password "12345678"	Sets the SAE password for network 0 to "12345678". This key is used for WPA3-SAE authentication.
14	wpa set sae_pwe 2	Sets the SAE mechanism for PWE derivation to 2, which enables both the hunting-and-pecking loop and the hash-to-element methods.
15	wpa enable_network 0	Enables network 0 in the wpa_supplicant configuration, making it active and ready to accept connections.

There is one important consideration regarding channel configuration.
Since the relay's AP and relay's STA operate concurrently on a single radio, both interfaces must use the same channel.

The station interface automatically follows the operating frequency of the parent AP and therefore does not require additional configuration. However, **the relay's AP must be explicitly configured to use the same channel as the relay's STA.**

Accordingly, in the example below, the channel frequency is set to 5805.
This is because, in Chapter 3, the parent AP is started using the default configuration, which operates on channel 161 (925 MHz) in the HaLow band. The legacy Wi-Fi channel frequency mapped to HaLow channel 161 corresponds to 5805 MHz.

This mapping information can be verified using the MAC80211_freq value shown in the output of the 'cli_app show config' command on the Host mode AP.

Table 4.1 SoftAP configuration commands

Configure wlan0 as a SoftAP using the following commands:

```
wpa set country US
wpa add_network
wpa set_network 0 ssid "halow_demo_relay_ap"
wpa set_network 0 pairwise CCMP
wpa set_network 0 group CCMP
wpa set_network 0 key_mgmt SAE
wpa set_network 0 proto RSN
wpa set_network 0 ieee80211w 2
wpa set_network 0 frequency 5805
wpa set_network 0 scan_freq 5805
wpa set_network 0 mode 2
wpa set_network 0 beacon_int 1000
wpa set_network 0 sae_password "12345678"
wpa set sae_pwe 2
wpa enable_network 0
```

4.2 Station Interface Configuration

Collectively, these commands configure and enable a Wi-Fi network connection for the station interface using wpb, allowing the device to connect to a specified Wi-Fi network with the defined security and operational parameters.

	Commands	Description
1	wpb add_network	Adds a new network configuration block in the wpa_supplicant configuration for the wpb interface. This creates a new network entry with an identifier, typically starting from 0.
2	wpb set_network 0 mode 0	Sets the mode for network 0 to 0, which configures the interface to operate as a STA
3	wpb set_network 0 ssid "halow_demo"	Sets the SSID (Service Set Identifier) for network 0 to "halow_demo". This is the name of the Wi-Fi network that the station interface will use to connect to the AP.
4	wpb set_network 0 proto RSN	Sets the protocol to RSN (Robust Security Network) for network 0. RSN is another name for WPA2, which provides stronger security than WPA.
5	wpb set_network 0 ieee80211w 2	Enables IEEE 802.11w (Protected Management Frames) for network 0. This setting protects management frames.
6	wpb set_network 0 key_mgmt SAE	Sets the key management protocol to WPA3-SAE for network 0.

7	wpb set_network 0 sae_password "12345678"	Sets the SAE password for network 0 to "12345678". This key is used for WPA3-SAE authentication.
8	wpb set sae_pwe 2	Sets the SAE mechanism for PWE derivation to 2, which enables both the hunting-and-pecking loop and the hash-to-element methods.
9	wpb enable_network 0	Enables network 0 in the wpa_supplicant configuration for the wpb interface, making it active and ready to connect to the specified Wi-Fi network.

Table 4.2 Station interface configuration commands

Configure wlan1 as a station using the following commands:

```
wpb add_network
wpb set_network 0 mode 0
wpb set_network 0 ssid "halow_demo"
wpb set_network 0 proto RSN
wpb set_network 0 ieee80211w 0
wpb set_network 0 key_mgmt SAE
wpb set_network 0 sae_password "12345678"
wpb set sae_pwe 2
wpb enable_network 0
```

4.3 Bridge Configuration

A network bridge interface is used to connect multiple network interfaces, allowing them to operate as a single logical network.

In the context of the NRC HaLow standalone relay configuration, the bridge interface combines wlan0 and wlan1, enabling seamless communication between devices connected to either interface. This configuration is essential for extending network coverage and maintaining end-to-end connectivity across the HaLow network.

In a relay configuration, wlan0 operates as an AP to extend HaLow network coverage by allowing additional stations to associate. The wlan1 interface, configured as a station, connects to a parent AP and provides upstream network connectivity. The bridge interface ensures that devices associated with wlan0 can communicate transparently with devices reachable through wlan1, thereby forming a unified network domain.

Set up the bridge for wlan0 and wlan1 using the following commands:

```
bridge addbr
bridge addif -A
```

4.4 Assigning IP Address

An IP address can be assigned to the bridge interface either dynamically or statically.

To assign a dynamic IP address to the bridge interface (br), use the following command:

```
dhcp -i br
```

To assign a static IP address, use the following command:

```
ifconfig br <address> [-n <netmask>] [-g <gateway>] [-m <mtu>] [-d<dns1 dns2>]
```

5 Using the sample application

To simplify the relay setup process described in Chapter 3, a sample application is included in the SDK to programmatically configure the relay.

The sample application is located under the following directory in the SDK:

```
sdk/apps/sample_wifi_relay
```

The application first creates a bridge interface that includes wlan0 and wlan1.
It then connects to the parent AP using wlan1 configured as a station, and subsequently creates an AP interface on wlan0 to allow additional stations to associate with the AP.

6 Revision history

Revision No	Date	Comments
Ver 1.0	05/30/2024	Initial version for customer release created
Ver 1.1	12/23/2025	Revised for the WPA3-SAE version