NRC7394 Application Note

(W5500 Ethernet)

Ultra-low power & Long-range Wi-Fi

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NEWRACOM, Inc.

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Ultra-low power & Long-range Wi-Fi

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1 Overview

Wiznet W5500 (https://www.wiznet.io/product-item/w5500/) is used to expand network connectivity while using NRC7394 chipset. SPI master interface on NRC7394 connected to W5500 ethernet chip to accomplish ethernet connectivity.

As seen on Figure 1.1, NRC7394 SPI master is connected to corresponding SPI slave pins on W5500.

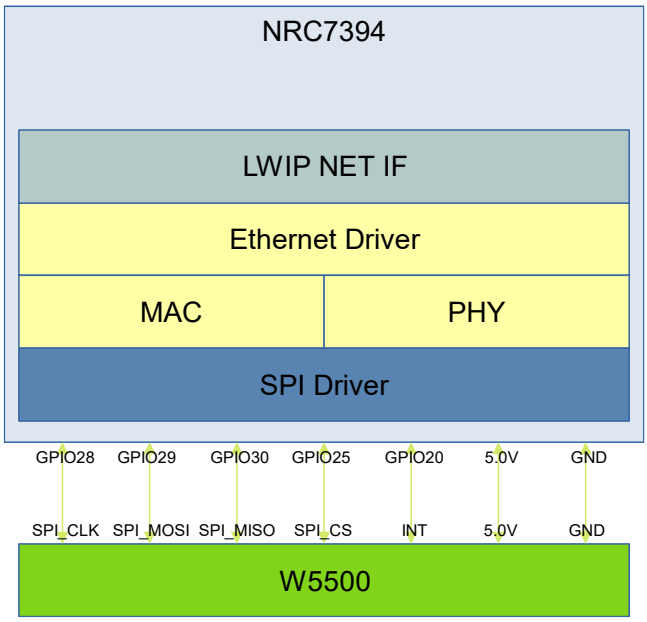

Figure 1-1 NRC7394/W5500 Connectivity

Below figure shows the HW block diagram that the firmware was prepared for. Hardware schematics can be provided if requested. The SPI clock speed used for the implementation is at 20MHz.

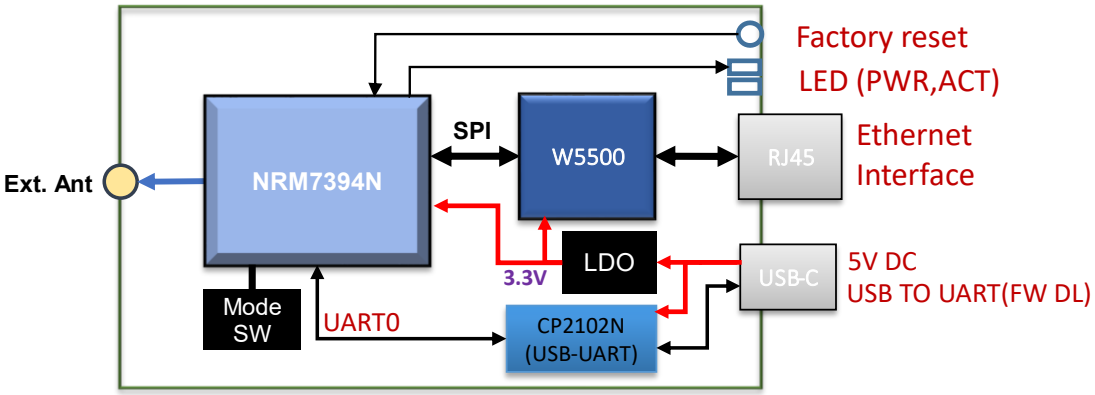

Figure 1-2 NRC7394/W5500 Block Diagram

2 Network Configuration

Various network configurations are supported based on user requirements. The focus on the software design is aimed to provide cleaner connectivity as well as flexibility that is compatible with computer data networks in general. NRC SDK has helper utility to configure Wireless network and it is in “sdk/apps/wifi_common” and the samples are provided for reference for the implementation.

There are 2 sample applications utilizing W5500 ethernet.

1. sdk/apps/sample_w5500_eth
2. sdk/apps/sample_w5500_nat

2.1 sample_w5500_eth

This sample supports various scenarios in network connectivity. It can act as Halow AP that provides connectivity between Halow station and existing network infrastructure through ethernet. This sample can be configured as a station that connects to Halow AP and provides connectivity to ethernet connected end device.

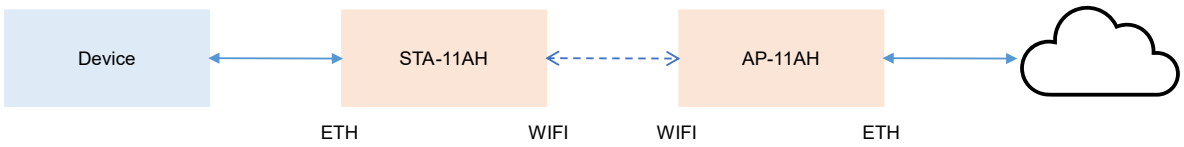

Figure 2-1 Network connectivity Illustrated

2.1.1 Soft AP

When the sample is built and installed on the NRC7394/W5500 device, the device will act as Halow AP. Soft AP can have its own DHCP server running that can provide IP addresses to Halow stations connected. The figure below shows how a station can be configured to have connections though AP. (See section 2.2 for detailed IP forwarding strategies.)

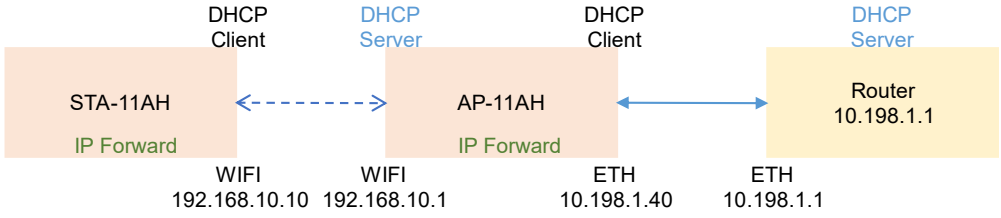

Figure 2-2 Example Soft AP configuration

2.1.2 Station

"sample_w5500_eth" application can be configured to become a WiFi station that provides network connectivity through ethernet to an end device. For this to work, a user can configure the device utilizing either a web browser or console. Detailed configuration how-to and example will be shown in chapter 3.

Figure 2-3 Station providing connection through ethernet

The above diagram shows how the end device can be connected to a station through ethernet to get network connectivity.

2.2 Traffic Forwarding Configuration

There are 2 packet forwarding mechanisms the sample application supports. One is through bridging the traffic between WiFi and ethernet interfaces and the other is through utilizing network address translation (NAT). Following sub chapters will explain details.

2.2.1 Bridge

If device is configured to utilize bridging, new network interface will be created as bridge interface. The ethernet interface will be added into the bridge as default. If the device configured as a soft AP, the WiFi interface will be also added into the bridge. On the other hand, if the device is configured as a station, WiFi interface will be added into the bridge once the WiFi pairing to AP is completed. Since the bridge is simply forwarding packets in and out, all the devices expected to be in the same subnet to communicate with each other.

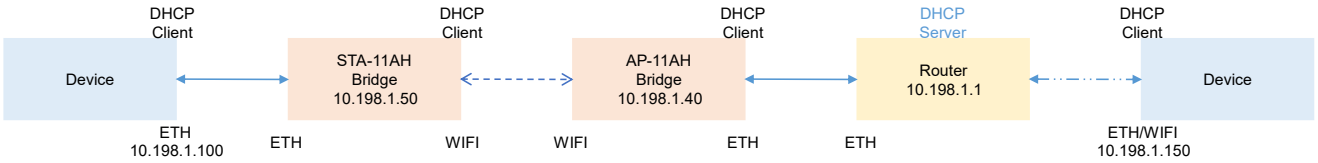

Figure 2-4 Bridge configuration

The above diagram shows an example bridge configuration where the IP addresses are assigned to each device from DHCP server running on the router. The network traffic is handled by the bridges in the station and Halow AP.

2.2.2 Network Address Translations (NAT)

Network address translation can be used on both stations and AP. When the traffic from the device connected to the ethernet interface on station reached the station, then source IP address for the packet will be replaced by the WiFi interface IP address. Once the packet is converted then the traffic will be forwarded to AP. AP will basically do the same action that the source IP address of incoming traffic coming from the WiFi interface will be changed to the IP of ethernet interface on AP. This traffic will be forwarded to device connected to ethernet interface on AP. Below diagram shows an example network topology.

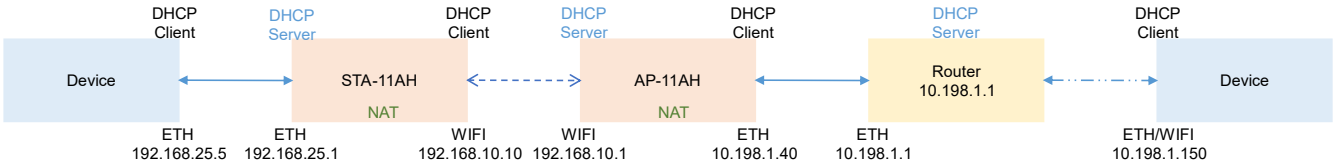

Figure 2-5 NAT configuration

Note how the IP addresses are assigned on each interface for the end-device, station and AP. With the above scheme, the end device connected to station through the ethernet interface will be able to communicate with the devices connected to the ethernet interface on AP. However, the device connected to the ethernet interface on AP will not be able to connect to either the station or the end device. Please see https://en.wikipedia.org/wiki/Network_address_translation for more information.

2.2.3 Hybrid configuration - bridge and NAT combinations

It is possible to configure the hybrid configuration utilizing both bridge and NAT. See below diagram showing the station utilizing NAT and bridge on AP.

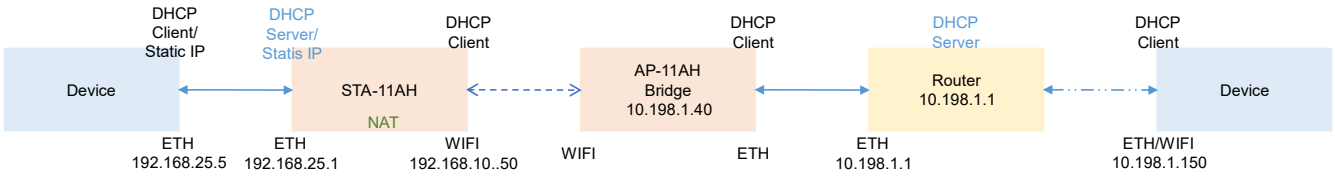

Figure 2-6 Bridge on AP and NAT on station

As shown above diagram, the incoming traffic reached by the ethernet interface on station will be translated and forwarded to AP. AP on the other hand will utilize the bridge to forward traffic.

2.3 Sample_w5500_nat

This sample application is much simplified to show how NAT can be programmed. No configuration is necessary, and the configuration can be done through API's provided and properly assign variables.

3 Building samples

Download the SDK available at https://github.com/newracom/nrc7394_sdk.
Download the toolchain “gcc-arm-none-eabi-10.3-2021.10-x86+64-linux.tar.bz2” available at https://developer.arm.com/downloads/-/gnu-rm

Extract the toolchain to somewhere on Ubuntu 64 bit PC, and set the PATH variable to where the toolchain compiler is available.

In nrc7394_sdk/package/standalone/ folder, execute following command to build the application firmware binary.

```
make select target=nrc7394.sdk.release APP_NAME=sample_w5500_eth
make
```

The output binary will be available in the folder nrc7394_sdk/package/standalone/out/nrc7394/standalone_xip/sample_w5500_eth/nrc7394_standalone_xip_sample_w5500_eth.bin

Flash the firmware on the device.

4 Wi-Fi Configuration In Web Server

4.1 Using a browser

"sample_w5500_eth" has its own web server built in and one can configure the device using a browser. Note that the default Network mode setting will be to use Bridge while using web browser to configure.

When the sample application firmware is written to the NRC7394/W5500 device, the device will have Halow AP running with the ethernet IP address set to 192.168.50.1. Connect the device through ethernet and configure static IP address for the ethernet on the computer to something like 192.168.50.x. (i.e., 192.168.50.2).

Open a browser and connect to http://192.168.50.1.

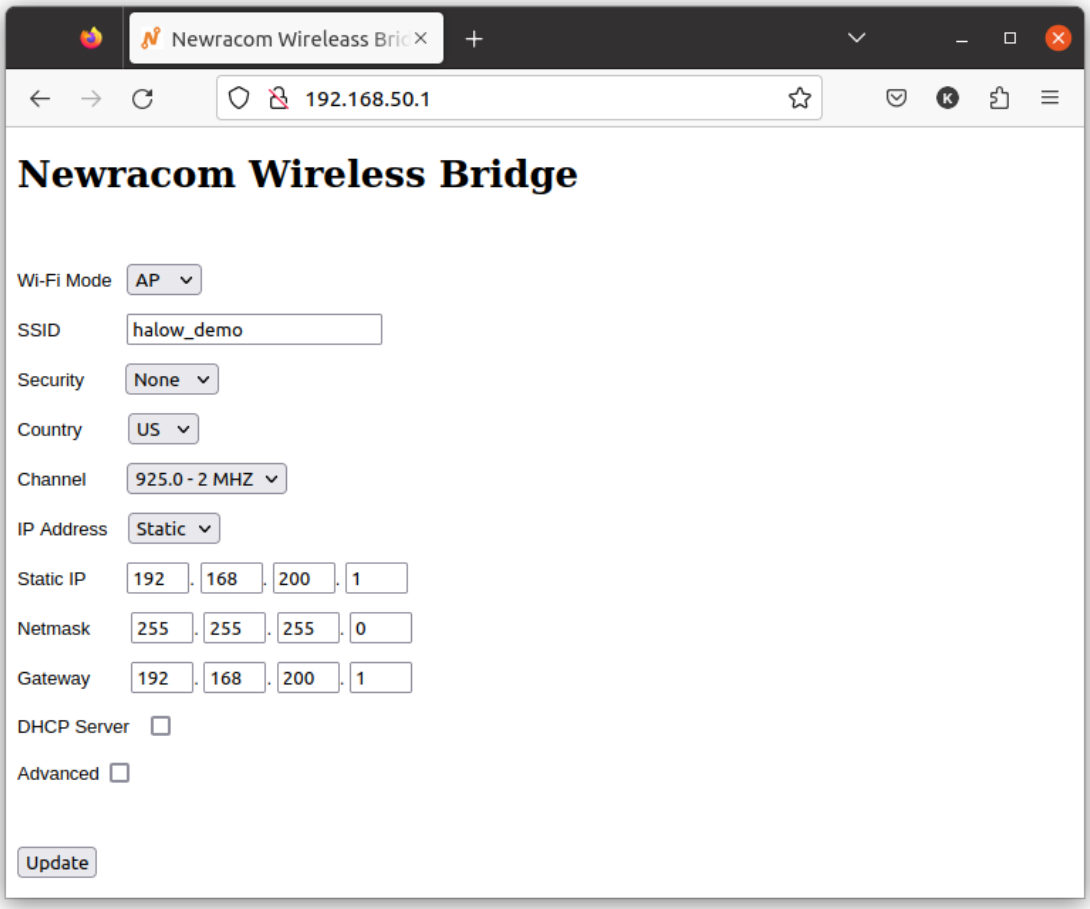

Figure 4-1 Default web server page

Once the browser connects to the web server running on NRC7394/W5500 device, it will show a page as shown in Figure3-1.

Field	Value	Default Value
Wi-Fi Mode	Setting whether the device will be running AP or station	AP
SSID	For AP, this field sets the SSID to be used. For a station, the device will look for a AP to be paired.	halow_demo
Security	WiFi security mode to be used.	None
Country	The device WiFi country setting.	US
Channel	Sub 1GHz channel to be used for AP.	925.0MHz with 2MHz bandwidth
IP Address	Whether to use static IP or DHCP	static
Static IP	If static ip is selected, IP address in this field will be assigned to the bridge interface	192.168.200.1
Netmask	IP Network mask to be used for static IP setting	255.255.255.0
Gateway	Gateway address to be used for static IP setting	192.168.200.1
DHCP server	Check box indicating whether to start DHCP server	False
Advanced	WiFi related settings	False

Table 4-1 NRC7394/W5500 WEB configuration items

If a user sets the appropriate values for the above fields and updates, the change will take place.

If the station mode will be used, then the page will be shown as Figure 3-2. Most of the fields descriptions are identical except the “Channel” setting will be removed since the station will be paired with AP on certain channel.

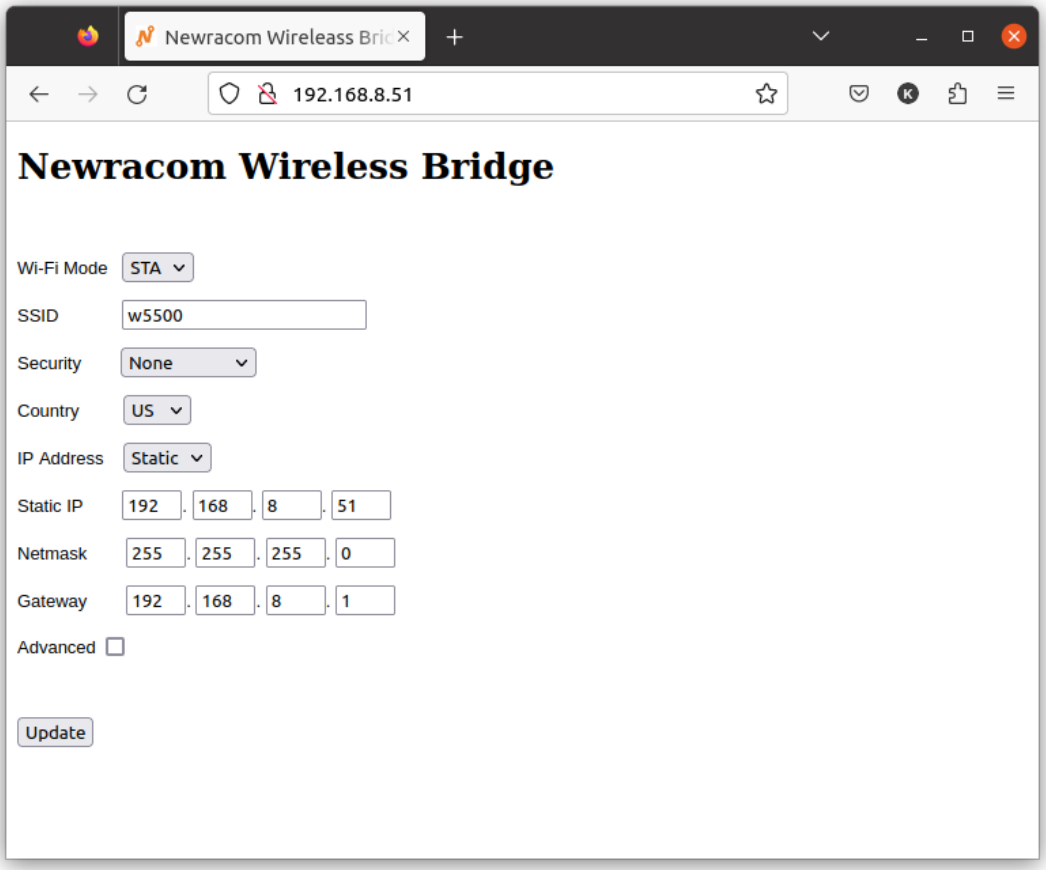

Figure 4-2 Station mode setting page

4.2 Using NVS subsystem

There are few configuration key/value pair that can be used to set the device behavior. The NVS subsystem key/value pair can be set by using the “nvs” command line utility while the console to the device is used. The full list of the configuration key/value pair details are available in sdk/apps/wifi_common/nvs_config.h.

Below table shows the most relevant configuration items that will change the device behavior.

Key	Type	Value	Default
device_mode	uint8_t	0: AP 1: Station	0
network_mode	uint8_t	0 : Bridge 1: NAT	0
ssid	string	SSID to be used for AP AP with SSID to pair to for a station	“halow_demo”
wifi_security	uint8_t	WiFi security to be used. 0 : open 1: wpa2psk 2: wpa3-OWE 3: wpa3-SAE	0
wifi_password	string	WiFi password for wpa2 and wpa3-SAE	“12345678” – Not used
ip_mode	uint8_t	0 : static 1: DHCP client to be used	0
wlan0_ip	string	Static IP address to be used. This value is set to bridge interface if bridge is used.	192.168.200.1
wlan0_netmask	string	Static netmask to be used. This value is set to bridge interface if bridge is used.	255.255.255.0
wlan0_gateway	string	Static gateway address to be used. This value is set to bridge interface if bridge is used.	192.168.200.1

Table 4-2 NRC7394/W5500 NVS configuration key/value items

Note: NVS console commands available are shown below.

1. help nvs will show NVS subsystem commands available.

```
[21] 208466893 nrc7292_standalone_xip>help nvs
nvs        - nvs key value read/write
Usage:
nvs {show (prints keys and types stored)|
    info (show statistics)|
    set key value (to set string value)|
    set_{i8,u8,i16,u16,i32,u32,i64,u64} key value (to set number value)|
    get key (to get string value)|
    get_{i8,u8,i16,u16,i32,u32,i64,u64} key (to get number value)|
            delete key (to delete key and its value)|
    commit (commit to flash - not used)|
    erase (erase nvs contents)|
    reset (erase flash area - low format)|
    dump (dump nvs partition information)}
OK
[22] 210392533 nrc7292_standalone_xip>
```

Table 4-3 Help nvs output

2. nvs show will show the key/value pair currently set in NVS subsystem.

```
[22] 210392533 nrc7292_standalone_xip>nvs show
key 'ssid', type 'string', value 'w5500'
key 'bssid', type 'string', value '00:00:00:00:00:00'
key 'country', type 'string', value 'US'
key 'wifi_security', type 'u8', value '0'
key 'wifi_password', type 'string', value '12345678'
key 'wifi_pmk', type 'string', value ''
key 'wifi_pmk_ssid', type 'string', value ''
key 'wifi_pmk_pw', type 'string', value ''
key 'wifi_channel', type 'u16', value '9250'
key 'wifi_channel_bw', type 'u8', value '0'
key 'wifi_bcn', type 'i32', value '1000'
key 'wifi_short_bcn', type 'i32', value '100'
key 'ip_mode', type 'u8', value '0'
key 'wlan0_netmask', type 'string', value '255.255.255.0'
key 'remote_address', type 'string', value '192.168.200.1'
key 'remote_port', type 'u16', value '8099'
key 'tx_power', type 'u8', value '24'
key 'tx_power_type', type 'u8', value '1'
key 'dhcps_on_wlan', type 'u8', value '0'
key 'conn_timeout', type 'i32', value '0'
key 'disconn_timeout', type 'i32', value '0'
key 'bss_max_idle', type 'i32', value '0'
key 'device_mode', type 'u8', value '1'
key 'network_mode', type 'u8', value '0'
key 'wifi_rc', type 'u8', value '1'
key 'wifi_mcs', type 'u8', value '10'
key 'wifi_gi', type 'u8', value '0'
key 'wifi_cca_thres', type 'i8', value '-75'
key 'hidden_ssid', type 'u8', value '0'
key 'wlan0_ip', type 'string', value '192.168.8.51'
key 'wlan0_gateway', type 'string', value '192.168.8.1'
OK
[23] 323483031 nrc7292_standalone_xip>
```

Table 4-4 nvs show command output

3. nvs set_u8 to set uint8_t type key/value.
4. nvs set to set string type key/value.
5. nvs delete <key> to delete key and value.
6. nvs erase to erase everything in nvs.

5 Revision history

Revision No	Date	Comments
Ver 1.0	08/15/2023	Initial version