



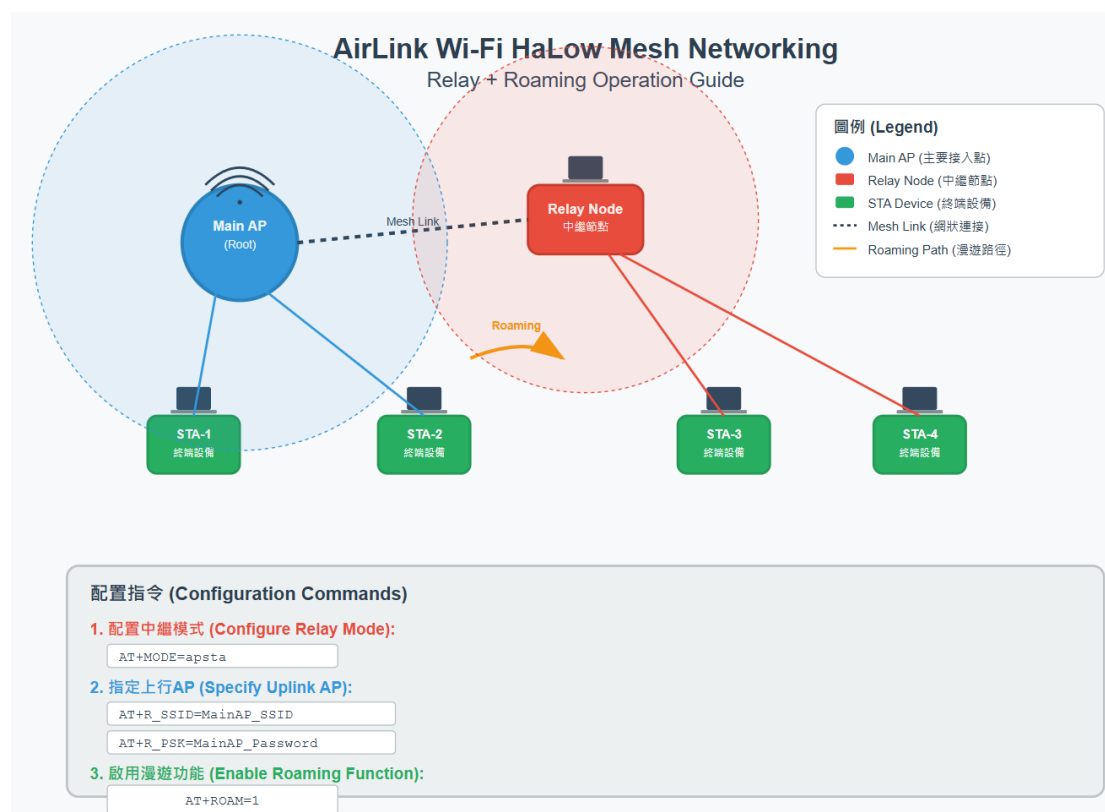
Wi-Fi HaLow Mesh Networking: Relay + Roaming Operation Guide

Executive Summary

This comprehensive guide provides step-by-step instructions for implementing Wi-Fi HaLow (802.11ah) mesh networking using AirLink modules. The solution enables advanced relay functionality, seamless roaming capabilities, and multi-hop mesh topology for extended coverage and robust connectivity.

Introduction to Wi-Fi HaLow Technology

Wi-Fi HaLow (802.11ah) is a low-power, long-range wireless communication standard operating in the Sub-1GHz frequency band. This technology is specifically designed for IoT applications requiring extended range, low power consumption, and reliable connectivity through obstacles.



Key Advantages

- Extended Range:** Up to 1km in open space
- Low Power Consumption:** Ideal for battery-powered devices



- **Better Penetration:** Sub-1GHz frequencies penetrate walls and obstacles effectively
- **Scalable:** Supports thousands of connected devices

Network Architecture Overview

Topology Structure

The Wi-Fi HaLow mesh network implements a hierarchical relay structure that extends coverage through multiple hops:

[Main Access Point]

|

[Relay Node 1] (AP+STA Mode)

|

[Relay Node 2] (AP+STA Mode)

|

[End Device/Station]

Component Roles

- **Main AP:** Primary access point providing internet connectivity
- **Relay Nodes:** Intermediate nodes operating in AP+STA mode for signal extension
- **End Devices:** Client stations connecting to the network

Configuration Guide

1. Main Access Point Setup

The main AP serves as the network's root node and internet gateway.

Configuration Commands:

AT+MODE=ap

Set to Access Point mode



AT+SSID=ah_main_ap # Set SSID (max 32 characters)

AT+KEYMGMT=none # Disable encryption (or WPA-PSK for security)

AT+CHAN_LIST=9080,9160,9240 # Set frequencies (908MHz, 916MHz, 924MHz)

AT+BSS_BW=8 # Set 8MHz bandwidth

Purpose: Establishes the primary access point for the mesh network foundation.

2. Relay Node Configuration

Relay nodes extend network coverage by simultaneously connecting upstream and serving downstream devices.

Configuration Commands:

AT+MODE=apsta # Enable dual STA+AP functionality

AT+R_SSID=ah_main_ap # Connect to upstream AP

AT+SSID=ah_relay1 # Broadcast SSID for downstream devices

AT+KEYMGMT=none # Security configuration

AT+CHAN_LIST=9080,9160,9240 # Match upstream AP frequencies

AT+BSS_BW=8 # Match upstream AP bandwidth

Key Features:

- Dual-mode operation (Station + Access Point)
- Transparent data forwarding
- Automatic upstream connection management

3. End Device Setup

End devices connect to the nearest available access point in the mesh network.

Configuration Commands:

AT+MODE=sta



AT+SSID=ah_relay1 # Connect to nearest relay or main AP

AT+KEYMGMT=none

Roaming Implementation

Enable Roaming Functionality

Activate roaming on all client devices (including relay nodes in STA mode):

AT+ROAM=1

SSID Strategy for Seamless Roaming

Option 1: Exact Match Method

- All access points use identical SSID: ah_mesh_ap
- Devices automatically connect to strongest signal
- Simplest implementation

Option 2: Fuzzy Match Method

- **Prefix-based naming:** Common string (>8 chars) + 3-digit ID
- **Example:** HUGE_IC_AH001, HUGE_IC_AH002, HUGE_IC_AH003
- **STA Configuration:** Match any one AP SSID for automatic roaming
- **Requirement:** Total SSID length must exceed 8 characters

Advanced Configuration Options

Performance Optimization

Bandwidth Configuration:

AT+BSS_BW=4 # Options: 1/2/4/8 MHz

Channel Management:

AT+CHAN_LIST=9080,9160,9240 # Specify available channels

Power Control:



AT+TXPOWER=20 # Adjust transmission power (dBm)

Network Monitoring

Signal Strength Monitoring:

AT+RSSI? # Check received signal strength

Connection Status:

AT+CONN_STATE # Verify connection status

Implementation Benefits

Technical Advantages

- **Multi-hop Extension:** Extends range without additional mesh protocols
- **Intelligent Roaming:** Built-in handoff logic for seamless connectivity
- **Sub-1GHz Operation:** Superior propagation characteristics
- **Power Efficiency:** Optimized for battery-powered applications

Operational Benefits

- **Easy Deployment:** Simple AT command configuration
- **Scalable Architecture:** Add nodes as needed
- **Robust Connectivity:** Automatic failover and recovery
- **Cost-effective:** Uses standard Wi-Fi infrastructure

Application Scenarios

Smart Agriculture

- **Greenhouse Monitoring:** Temperature, humidity, soil sensors
- **Field Management:** Crop monitoring across large areas
- **Irrigation Control:** Remote valve and pump management

Industrial Automation



- **Factory Floor:** Machine status monitoring
- **Warehouse Management:** Inventory tracking systems
- **Process Control:** Remote sensor networks

Infrastructure Monitoring

- **Remote Cameras:** Security and surveillance applications
- **Environmental Sensors:** Air quality, weather monitoring
- **Asset Tracking:** Equipment and vehicle location

Smart City Applications

- **Street Lighting:** Intelligent lighting control
- **Parking Management:** Space availability monitoring
- **Public Safety:** Emergency alert systems

Troubleshooting Guide

Common Issues and Solutions

Connection Problems:

1. Verify SSID matching between devices
2. Check signal strength with AT+RSSI?
3. Confirm channel availability

Roaming Issues:

1. Ensure AT+ROAM=1 is enabled on all client devices
2. Verify overlapping coverage areas
3. Check SSID naming consistency

Performance Optimization:

1. Adjust AT+TXPOWER for optimal range vs. power consumption



2. Select appropriate AT+BSS_BW for throughput requirements
3. Use AT+CHAN_LIST to avoid interference

Best Practices

Network Design

- Position relay nodes for optimal coverage overlap
- Maintain signal strength above -70 dBm for reliable operation
- Plan for redundant paths in critical applications

Security Considerations

- Implement WPA2/WPA3 security when required
- Use network segmentation for sensitive applications
- Regular firmware updates for security patches

Maintenance

- Monitor signal strength regularly
- Update device configurations as network grows
- Document network topology for troubleshooting

Technical Reference

AT Command Summary

Command	Purpose	Example
AT+MODE	Set device operation mode	AT+MODE=apsta
AT+SSID	Configure broadcast SSID	AT+SSID=ah_mesh_ap
AT+R_SSID	Set upstream connection SSID	AT+R_SSID=ah_main_ap
AT+ROAM	Enable roaming functionality	AT+ROAM=1



Command	Purpose	Example
AT+CHAN_LIST	Set frequency list	AT+CHAN_LIST=9080,9160,9240
AT+FREQ_RANGE	Set frequency range	AT+FREQ_RANGE=9080,9240
AT+TXPOWER	Configure transmission power	AT+TXPOWER=20

Documentation References

- AH Module AT Command Development Guide, v3.0
- IEEE 802.11ah Standard Specification
- AirLink/Taixin Module Technical Manual

Conclusion

Wi-Fi HaLow mesh networking with relay and roaming capabilities provides a robust, scalable solution for IoT applications requiring extended range and reliable connectivity. The simple AT command interface makes deployment straightforward while maintaining enterprise-grade functionality.

For additional support or advanced configurations, please consult the official documentation or contact technical support.

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