WT303-WS203 Hundred-unit Scenario Test Report (PIR Linkage Success Rate)

1. Project Overview

1. Project Background

- This report evaluates a LoRaWAN-based HVAC occupancy control deployment in hospitality environments, through the WS203 PIR occupancy sensor to sense the room occupancy status, and link with the WT303 fan coil thermostat to achieve automated air conditioning management of "Comfortable When Occupied, Energy-Saving When Unoccupied".

2. Test Objectives

Test Objectives	Specific Indicators
Reliability of 100 PIR Linked Communication	WS203 (triggered by occupied/unoccupied) → UG65 (send downlink command) → WT303 (report execution status) The number of groups with a success rate of over 99% ≥ 99%
Establish a reliable success rate estimation model	Output a reference model based on the results of 100 scenario tests, and provide deployment recommendations for 650 sets of device scenarios
Deployment recommendations for similar applications	Gradually optimize model parameters and redundancy coefficients to provide reference suggestions for subsequent deployment of relevant scenarios

3. Test Conclusion

Project	Content
Project Name	WT303-WS203 Hundred-unit Scenario PIR Linkage Success Rate Test
Application Scenarios	Hotel Indoor LoRaWAN Wireless Linkage (Comfortable for Occupancy, Energy-Saving for Vacancy)

Test Cycle	2026-03-09 ~ 2026-03-26
Final Test Period	2026-03-20 ~ 2026-03-26 (estimated data volume: 200, 000)
Report Version	V1.0
Test Conclusion	Under the conditions of [II. Test Environment], the test passed (including the conclusion of passing obtained through AI model calculation)

2. Test Environment

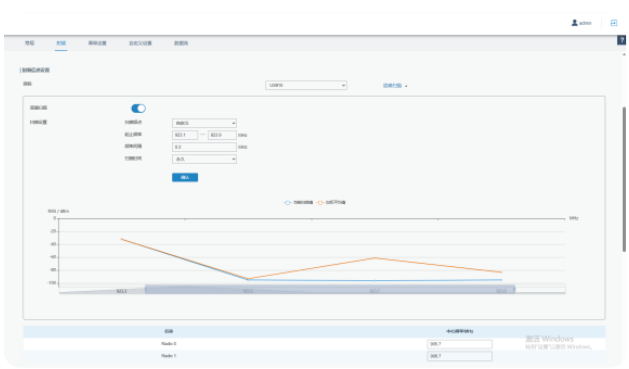
1. Environment Deployment

1.1 Equipment List

Device	Model	Quantity	Role
PIR Sensor	WS203	100 units	Upstream Trigger Terminal
Fan Coil Thermostat	WT303	100 units	Downstream Execution End
Main Gateway	UG65	1 unit	Packet reception, Node-RED processing, and downlink scheduling
From the gateway	UG65	1 unit (+2 units for commissioning backup)	Listen + Send (Packet Forwarding Mode)

1.2 Ambient Noise

Upstream frequency floor noise: -93 dBm (real-time)



Downlink Frequency Band Noise Floor: -94 dBm (Real-time)

1.3 Final Test Parameter Configuration

Parameter	WS203	WT303
Frequency Band	US915	US915
Frequency Point	16-23	16-23
Number of Gateways	2 units	
Spreading Factor	SF9	SF9
Reporting Cycle	4 min	10 min
Confirmation Packet	Enable	Disable
ADR	Disable	Disable
Network Access Method	OTAA	OTAA
Gateway Downlink Frequency	—	923.9 MHz
Gateway Downlink Rate	—	SF10

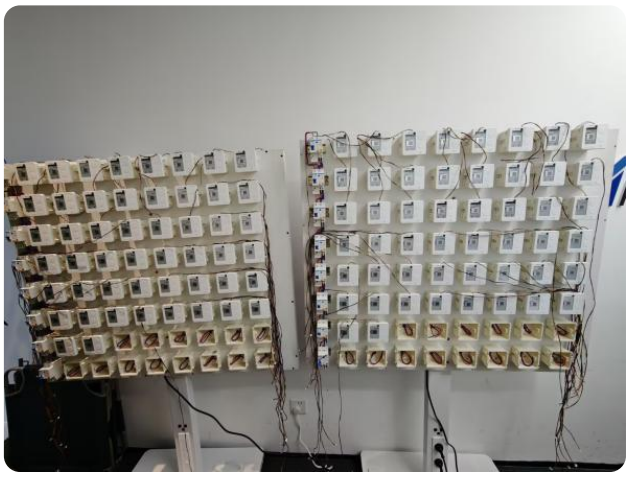
1.4 Gateway Configuration

- Main Gateway: Set the frequency band to US915, select the frequency point with the least interference for background noise scanning; batch import 200 devices; fix the downlink frequency of WT303 at 923.7 MHz; enable packet logging
- Secondary gateway: Packet forwarding mode, monitoring and distribution, enable packet logging

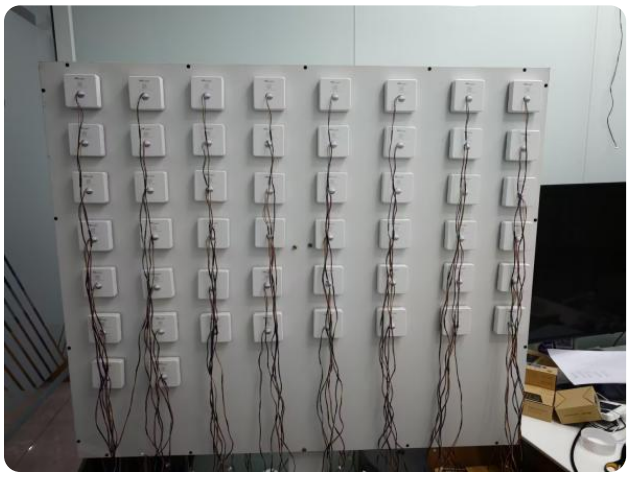
1.5 Node Configuration

- WS203: Configure PIR idle reporting time to 60 minutes to avoid conflicts
- WT303: All devices are connected to the serial port and serial port logs are recorded to facilitate troubleshooting of anomalies

1.6 Test Scenario



WT303



WS203

2. Software Debugging Environment Setup

UG65 has built-in Node-RED, imports a custom Node-RED workflow (flows_100g_retry.json, 129 nodes), and the core logic is:

- **Trigger Logic:** After the gateway receives the WS203 uplink periodic packet, it triggers a downlink command; duplicate uplink packets identified by identical FCnt values is identified and recorded
- **Duplicate command suppression:** While awaiting acknowledgment, new cycle packets are only recorded but not sent out, waiting for the current process to complete
- **Retry mechanism:** Retry up to 2 times after the first delivery, with a random interval of 20-30 seconds, and a total timeout of 120 seconds
- **Data Recording:** Each group independently counts the distribution of ACK/Failure/Packet loss/Retry; all events are written to a CSV log

3. Communication success determination logic

- WS203 Report Period Packet → Reached Gateway
- The gateway sends a confirmed downlink command to WT303 (RX2 window, SF10 BW500)
- WT303 (Class C) receives confirmation packet → replies with ACK (SF9 BW125)
- Gateway receives ACK → Record as "Success"
- If ACK is not received → Automatic retry, with a random interval of 20~30 s, up to 2 times
- All retries failed → Recorded as "Failed"

4. Success rate calculation method

Success rate formula:

Overall success rate = Number of ACK confirmations ÷ (Number of ACK confirmations + Number of complete failures + Number of lost WS203 uplink packets)

Actual scenario success rate = Number of occupancy/vacancy trigger events ÷ (Number of occupancy/vacancy trigger events + Number of linkage failures + Number of uplink packet losses for triggering/releasing)

Explanation of overall success rate calculation

Explanation of overall success rate calculation:

Explanation of ACK confirmation count: In actual scenarios, after WT303 successfully performs the action of adjusting the air conditioner state, it will report the current state, indicating that the trigger was successful

Explanation of complete failures: In the actual scenario, after WS203 is triggered, the system performs the initial transmission followed by up to two retries. If WT303 does not send the status after execution within the timeout period (120 s, adjusted according to actual conditions), it means the linkage has failed.

Explanation of the Number of lost WS203 uplink packets: In actual scenarios, it means that after someone triggers an uplink packet, the gateway fails to receive the expected status packet due to interference between devices or the environment, resulting in the failure of the linkage.

Uplink retransmission of WS203 open confirmation packet (with the same FCnt) is not counted in the denominator

5. Test conclusion judgment criteria

Judgment criteria:

Final success rate = Number of groups with actual success rate ≥ 99% ÷ Total number of device groups ≈ Number of groups with AI model success rate ≥ 99% ÷ Total number of device groups

Based on the aggregation of the above test data, we established **an AI model**. The theoretical calculations of this model are basically consistent with the success rate of actual tests (one key objective of this test is to validate the AI model's theoretical predictions against real-world results), and it can relatively accurately output the number of non-compliant groups under theoretical conditions, thereby obtaining the ideal configuration for scenarios with different numbers of devices

3. Success Rate Tuning Journey

Serial number	Date	Test time	Data volume	Number of gateways	Parameter Description	WT303 Cycle	Spreading Factor	Gateway downlink rate	WS203 Cycle	Retry	Interval	Overall success rate	Remarks
1	3-16 Up	9 h 40 min	12096	1 Master + 3 Slaves	1. The frequency points (16-23) of the two gateways are used for receiving uplink packets of WS203 2. The frequency points (48-55) of the two gateways are used for receiving WT303 uplink packets.	10 min	SF7	SF7	5 min	2 times	Fixed for 10 seconds	99.78%	Pre-debugging stage
2	3.16~3.17	13 h 30 min	45155	1 Master + 3 Slaves		10 min	SF7	SF7	2 min	2 times	Fixed for 10 seconds	99.06%	SF7 is not applicable in real-world scenarios
3	3.17 evening ~ 3.18 morning	12 h 30 min	40277	1 Master + 3 Slaves		10 min	SF10	SF10	2 min	2 times	Fixed for 10 seconds	85.85%	SF10 unpacking causes high load and high packet loss rate
4	3.18~3.19	3 h	3758	1 Master + 1 Slave	Two gateway frequency points (16-23) are used for receiving uplink packets from WS203 and WT303	10 min	SF10	SF7	2 min	2 times	Fixed for 10 seconds	98.72%	Reducing the number of gateways, the transmission rate SF7 is not applicable in real scenarios
5	Evening of March 18th to Morning of March 19th	11 h	17419	1 Master + 1 Slave		10 min	SF10	SF10	4 min	2 times	Fixed for 20 s	95.46%	Retry time is fixed, and the conflict probability is relatively high
6	Evening of March 19th to Morning of March 20th	12 h	9421	1 Master + 1 Slave		10 min	SF10	SF10	8 min	3 times	Random 20~30 s	99.39%	Retry time is randomized to reduce conflicts while introducing a data model
7	Evening of March 20th to afternoon of March 26th	135 h	202111	1 Master + 1 Slave		10 min	SF9	SF10	4 min	2 times	Random 20~30 s	99.18%	Verify the accuracy of model data

Key Tuning Conclusions:

- Prioritize

Gateway Delivery Method: Without the confirmation packet mode enabled, after the gateway delivers a service, the device will report the corresponding status after execution. Due to the impact of the gateway's confirmation packet delivery mechanism, it is recommended that the end-user deployment not enable the confirmation packet mode.

Reporting Cycle: During the continuous stress test, the reporting cycle of WS203 is a core parameter and can be appropriately extended according to the actual situation. In actual scenarios, PIR triggering has a certain idle time, with relatively small conflict interference.

Spreading Factor Selection: SF7 has weak penetration, considering it is not suitable for the actual hotel wall environment, and due to the byte number limitation of the SF10 spreading factor, each report increases the number of periodic packets, leading to conflicts. Therefore, SF9 was selected for the final continuous stress test.

Downlink Rate: reduce transmission collisions

- If the success rate of the above solution is still low, consider the following approach

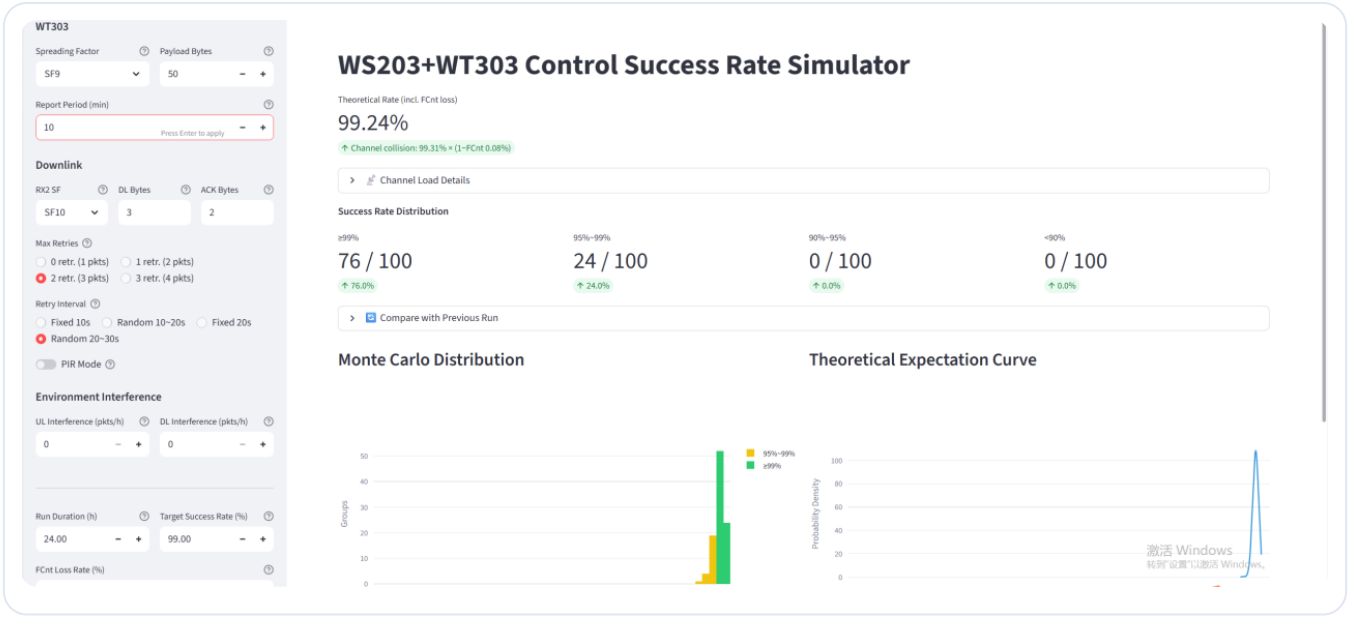
Retry Interval: After introducing a 20~30 s random jitter, it effectively disperses the instantaneous congestion caused by the synchronous retry of multiple groups of devices

Number of Gateways: Increasing the number of gateways based on the number of nodes and differentiating uplink frequency points can effectively alleviate uplink and downlink conflicts and reduce the probability of collisions. However, considering that differentiating frequency points is relatively inconvenient to configure in actual scenarios

4. Presentation of Final Test Data

Test Data Summary

> The overall success rate of the final solution in testing 200, 000 sets of data reached **99.26%**, with the success rate of all 100 sets of devices above 90%, and the proportion of single devices with a success rate of 99% or higher **72%**. Among them, for devices that did not reach 99%, WS203 uplink packet loss accounted for a disproportionate share of failures. If we want to improve the success rate, appropriately extending the uplink time of nodes can increase the success rate. By using AI to establish an analysis model and providing parameters such as packet sending interval, packet sending byte count, spreading factor, retry count, number of gateways, number of devices, and number of air interference packets, we can analyze and calculate success rate data. According to the analysis results of the model, under the same configuration scenario as described above, the overall success rate is **99.26%**, the proportion of single-unit success rates of 99% and above is **76%**, **which is basically consistent with the actual test success rate.**



Indicator	Result	Acceptance Criteria
Total number of WS203 uplinks	202111	200000
Overall linkage success rate (2 retries)	99.26%	≥ 99%
First downlink success rate	84.63%	—
Success rate of retrying once	96.99%	—
Minimum success rate per group	97.48%	—
Number of interfering devices during the process	154 devices (addresses not belonging to the 200 devices under continuous stress test)	
Number of interfering devices during the process	23613	accounts for 10.46%
≥ 99% Qualified Group Count/ Success Rate	72 groups / 72%	≥ 99%
<99% Group Count	28 groups	—
Device online rate	100%	= 100%
Continuous operation duration	135 h	—

5. Conclusions and Recommendations

1. Instructions for Using AI Models

- Based on the test results of the previous sf7 and 4 gateways, we have determined that our continuous stress test method is reasonable and effective, and the success rate meets the target;
- Based on the test conclusions of sf10 and the remaining 2 gateways, combined with the failure analysis, it was determined that the failure was caused by LoRa packet conflicts. Meanwhile, the test plan along with device configuration of each device was submitted to AI for analysis, and the success rate data obtained was basically consistent with the test results.
- For the convenience of continuous stress tests, we process the WT303 downlink every time the WS203 uplinks, which increases LoRa working conflicts. In reality, the WT303 downlink is only processed when the occupancy status changes, and the conflict in the real-world collision probability is expected to be lower than in the stress-test environment. the measured success rate is therefore a conservative estimate of real-world performance.

2. Combining the continuous stress test data and AI analysis model, the on-site configuration of 650 sets of Client devices is as follows:

Configuration 1:

Condition	Configuration Requirements	Description
Device Quantity	650+650	Actual number of devices
Number of Gateways	2 units (master-slave mode)	Under PIR trigger mode, the probability of conflict and collision between devices is relatively low, but due to wall factors, it may not fully cover all devices in the entire building. Therefore, at least two gateways need to be separately deployed to achieve wider coverage.
Gateway Delivery Method	Issue a non-opening confirmation packet	After the gateway issues a control command, the device will report the status after execution
WS203 Spreading Factor	SF9	When using SF10, if each uplink is requires multiple transmissions due to payload limitations, network load increases substantially

WS203 Report	Enable Confirmation Packet Mode	Ensure that the gateway can receive the status packet normally after PIR is triggered
WS203 Cycle	≥ 30 min	A too short cycle leads to channel overload
WT303 Cycle	≥ 10 min	Continuously monitor to ensure the reception of RX2 downlink
WT303 Spreading Factor	SF9	When SF10, each uplink is split into 6 packets, with a relatively high load
Number of PIR Triggers	10 times	
Retry Count	≥ 2 times	The success rate of 0 retries decreases by approximately 5-8%
Success Rate	≥ 99%	After the above configuration, it can meet 99% of the requirements

Configuration 2:

Condition	Configuration Requirements	Description
Number of Devices	650+650	Actual number of devices
Number of Gateways	3 units (master-slave mode)	In PIR trigger mode, the probability of conflict and collision between devices is relatively low, but due to wall factors, it may not fully cover all devices in the entire building. Therefore, at least two gateways need to be deployed separately to achieve wider coverage.
Gateway delivery method	Send out non-opening confirmation packet	After the gateway issues a control command, the device will report the state after execution
WS203 Spreading Factor	SF9	When using SF10, if each uplink is requires multiple transmissions due to payload

		limitations, network load increases substantially
WS203 Report	Enable Confirmation Packet Mode	Ensure that the gateway can receive the status packet normally after PIR is triggered
WS203 Cycle	≥ 10 min	A cycle that is too short leads to channel overload
WT303 Cycle	≥ 10 min	Continuously monitor to ensure the reception of RX2 downlink
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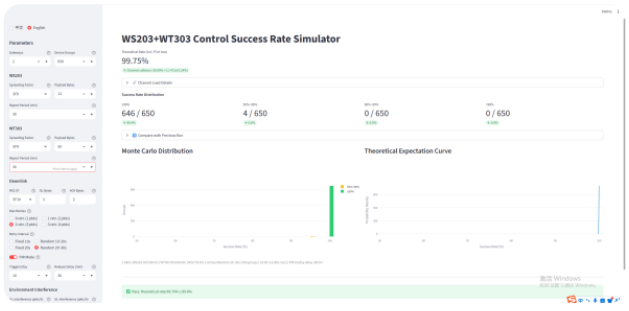
Number of PIR Triggers	10 times	
Retry Count	≥ 2 times	The success rate of 0 retries decreases by approximately 5-8%
Success Rate	≥ 99%	After the above configuration, it can meet 99% of the requirements

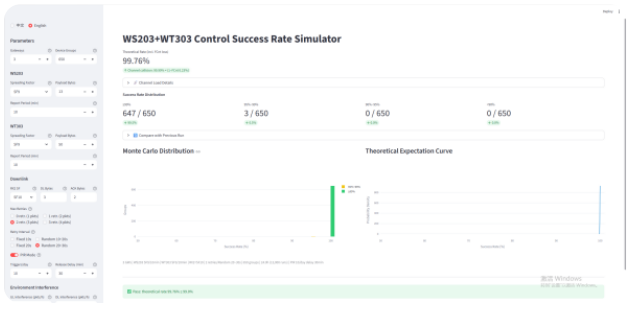
3. Device configuration process under scenario (taking Configuration 1 as an example, with the control success rate of all 650 groups ≥ 99%)

Step 1: Scenario Simulation Configuration

- Use model tools to simulate the appropriate configuration and corresponding success rate of 650 sets of devices, assuming 10 PIR trigger times per day (adjustable according to actual situation) and 2 gateways (master-slave mode)
- Check if the theoretical success rate of the model meets the requirements, and make configuration modifications based on the recommendations



Configure one



Configuration two

Step 2: Gateway background noise scanning

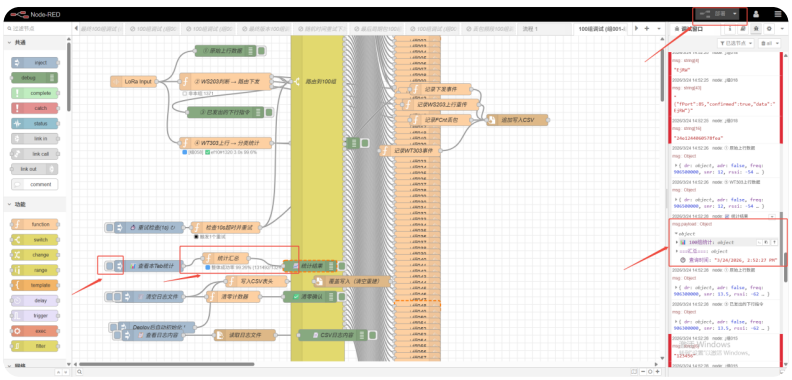
- Scan the uplink frequency points, select the uplink frequency point with the lowest possible noise floor for configuration, and set the channels of the master and slave gateways to be the same
- Scan the downlink frequency band, focusing on the WT303 RX2 window configuration. It is necessary to modify the RX2 rate and channel frequency in the advanced options of the profiles file.
- WT303 is recommended to be configured with RX2 rate SF10 and channel frequency 923.9 MHz.
- The window 2 of WS203 is recommended to be different from that of WT303. Because the probability of using window 2 of WS203 is very small, and usually it is window 1.

Step 3: WT303/WS203 Configuration

- The default reporting period for WS203 is set to 30 minutes, the default reporting period for WT303 is set to 10 minutes, the idle reporting period for WS203 is 30 minutes, the spreading factor is modified to SF9 for all, and all devices are imported into the gateway
- Wait for a period of time to confirm whether all devices have successfully joined the network, and after joining the network, confirm whether the WT303 receiving window is the same as the configuration in the profiles file
- It is necessary to confirm whether the signal-to-noise ratio (SNR) of all devices is greater than 0 (SNR > 0 dB indicates adequate link margin), spreading factor `SF9, recommended SNR ≥ -7.5 dB`, if not meeting the standard, it is recommended to deploy gateways across different areas or increase the number of gateways

Step 4: Script Configuration and Usage

- Import the script into Node-RED, click Deploy, and you can then control it normally



- Click to view the statistics of this tab to check the success rate in the statistical summary
- Details of the success rate for each group can be presented in the log window. You need to copy this value to Excel to view the success rate for each group.

Tuning Suggestions:

- Increase the number of gateways
- Extend the device reporting cycle