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CONNECTED INTELLIGENCE

Wi-SUN Large Network Monitoring and Performance Testing

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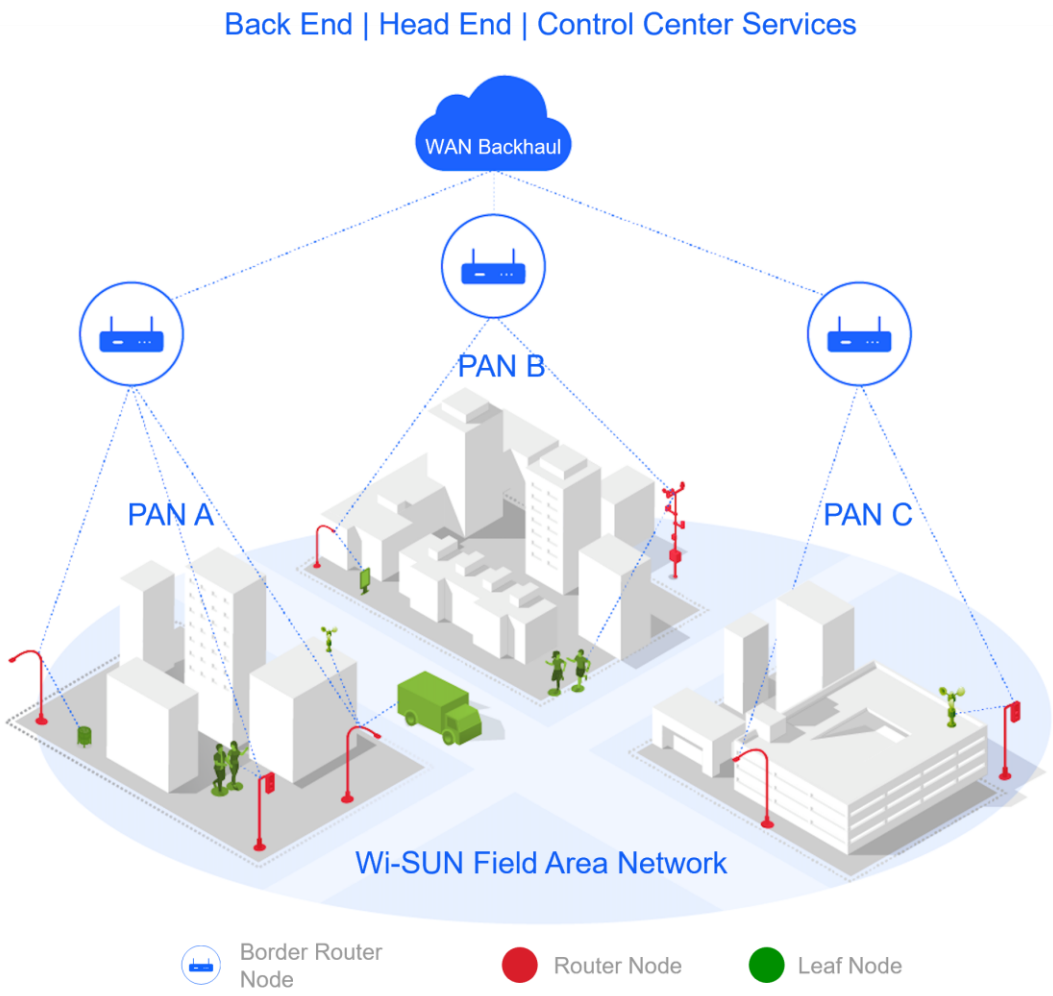
Wi-SUN

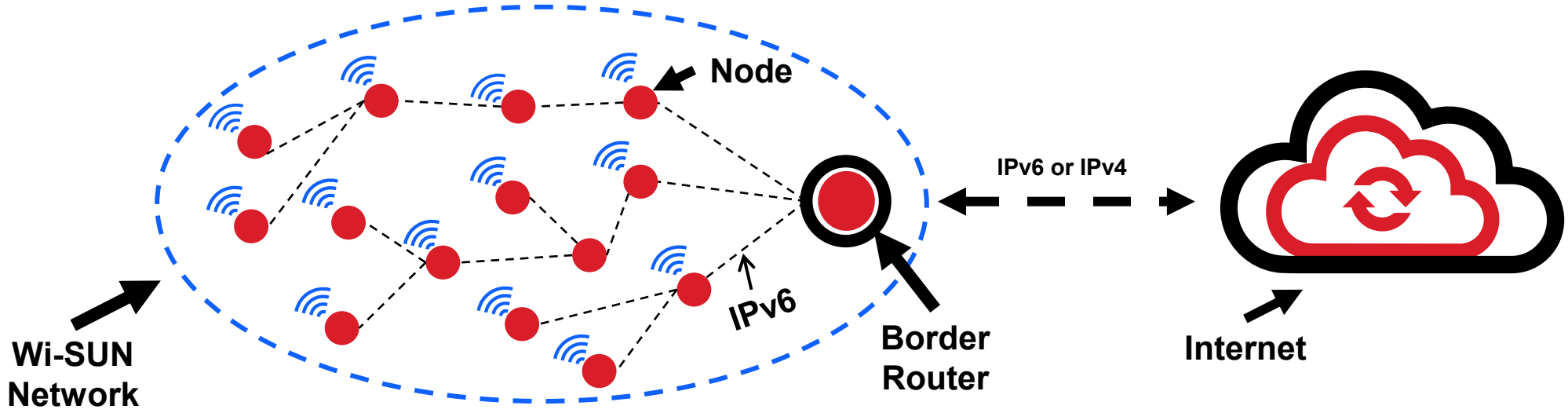
Wireless Smart Ubiquitous Network

Wi-SUN Solution Keywords



- **Wi-SUN**
  - Wireless smart utility network
- **Border Router**
  - Provides WAN connectivity
  - Maintains source routing tables
  - Node authentication and key mgmt.
  - Disseminate PAN-wide information such as broadcast schedules
- **Router Nodes**
  - Upward and downward packet forwarding within a PAN
  - Services for relaying security and address management protocols
- **Leaf Nodes**
  - Discover and join a PAN
  - Battery-powered devices
  - Send/receive IPv6 packets

Wi-SUN Stack and Network Architecture



IPV6 STACK SUITE

- TCP/UDP
- 6LoWPAN Adaptation + Header Compression
- DHCPv6 for IP address management
- Routing using RPL
- ICMPv6
- Unicast and Multicast forwarding

MAC AND PHY BASED ON IEEE802.15.4

- Frequency hopping
- Discovery/Join
- Various data rates and regions
  - FSK: 50-300 kbps
  - OFDM: 100-2400 kbps

Wi-SUN Large scale outdoor Applications

Smart Meters

EV Chargers

Parking Meters

Flow rate, Valve Control

Smart Agriculture

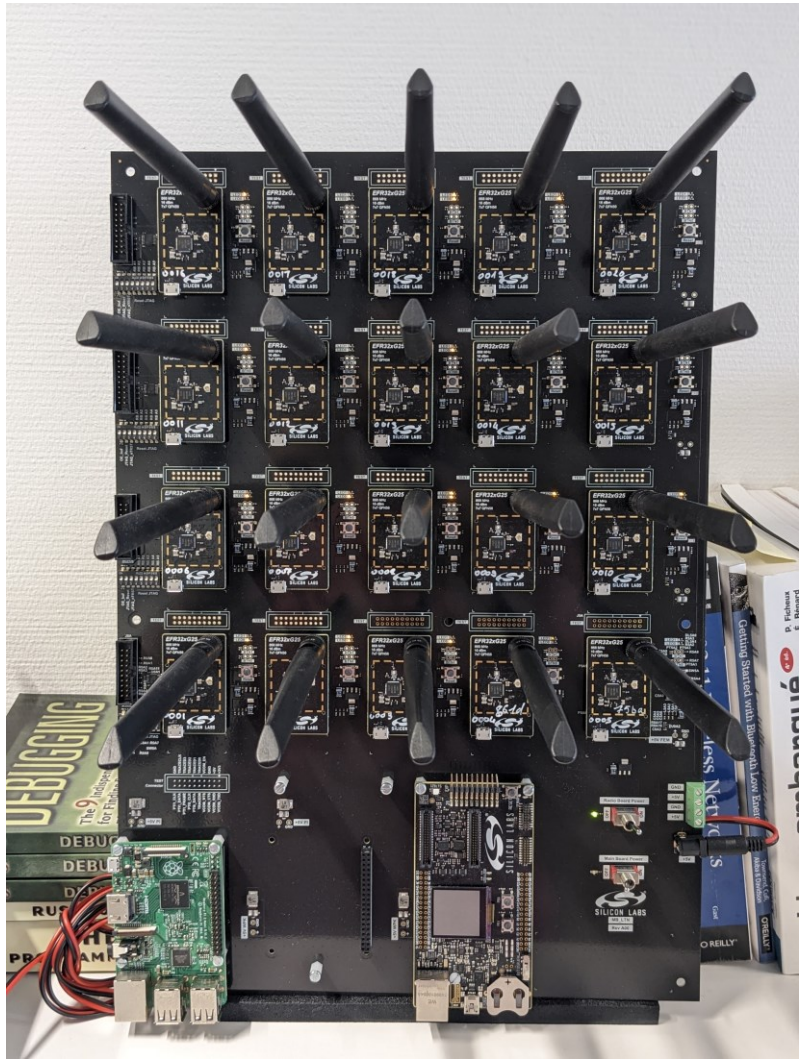
Office Large Wi-SUN Network

Large Network Phase One

- **250 Radio Board**
- **EFR32FG28 Explorer Kit**
- **All connected using a Power hub**

- **Limited Flash**
  - Updates should be performed one by one

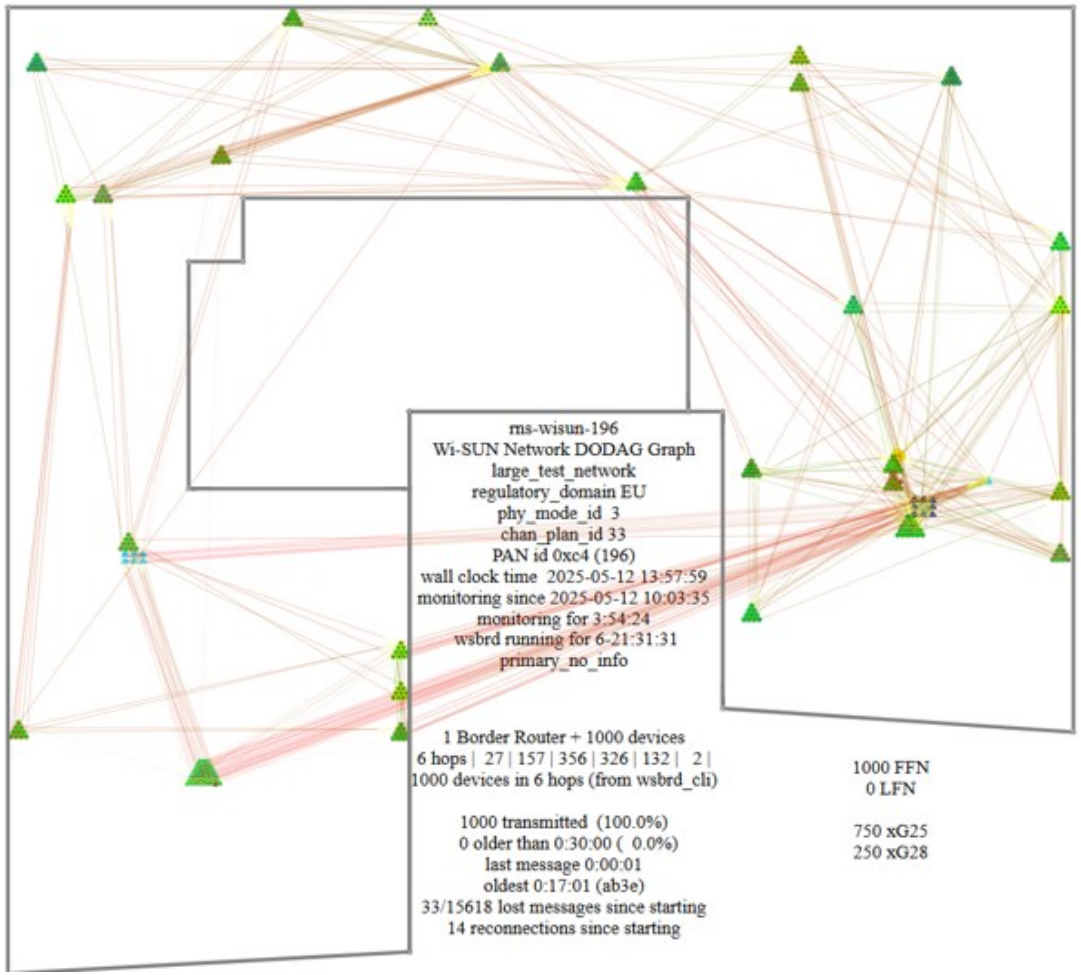
Large network Phase Two



- **New Main Board**
  - 20 radio boards fit on the Main Board
    - Buttons, LEDs and Reset for each Radio Board
    - Supports FG25, FG28 radio boards, including BRD4276A (FG25 + FEM)
  - 1 JTAG connector per row to flash daisy chained boards
    - Useful for initial programming
    - Updates through OTA
  - Single 5V power supply
  - Flexible Bottom slots
    - WPK + RB and Raspberry Pi to be used for
      - Linux Border Router, Linux Router or Direct Connect device
      - SoC BR, regular node (with Ethernet capability), LFN node with energy profiler
- **750 nodes added using the new Board**

1000 Nodes

- **Layout of the nodes in the building:**
  - On both 4th and 5th floor
- **PHY used: 100 kbps, EU1 band (863-870 MHz)**
- **Total 1000 nodes, all FFNs so far**
  - 750x FG25
  - 250x FG28
- **Each node sends status data every 15 min**
  - 99.8% success rate
- **The network forms in 6 or 7 hops**

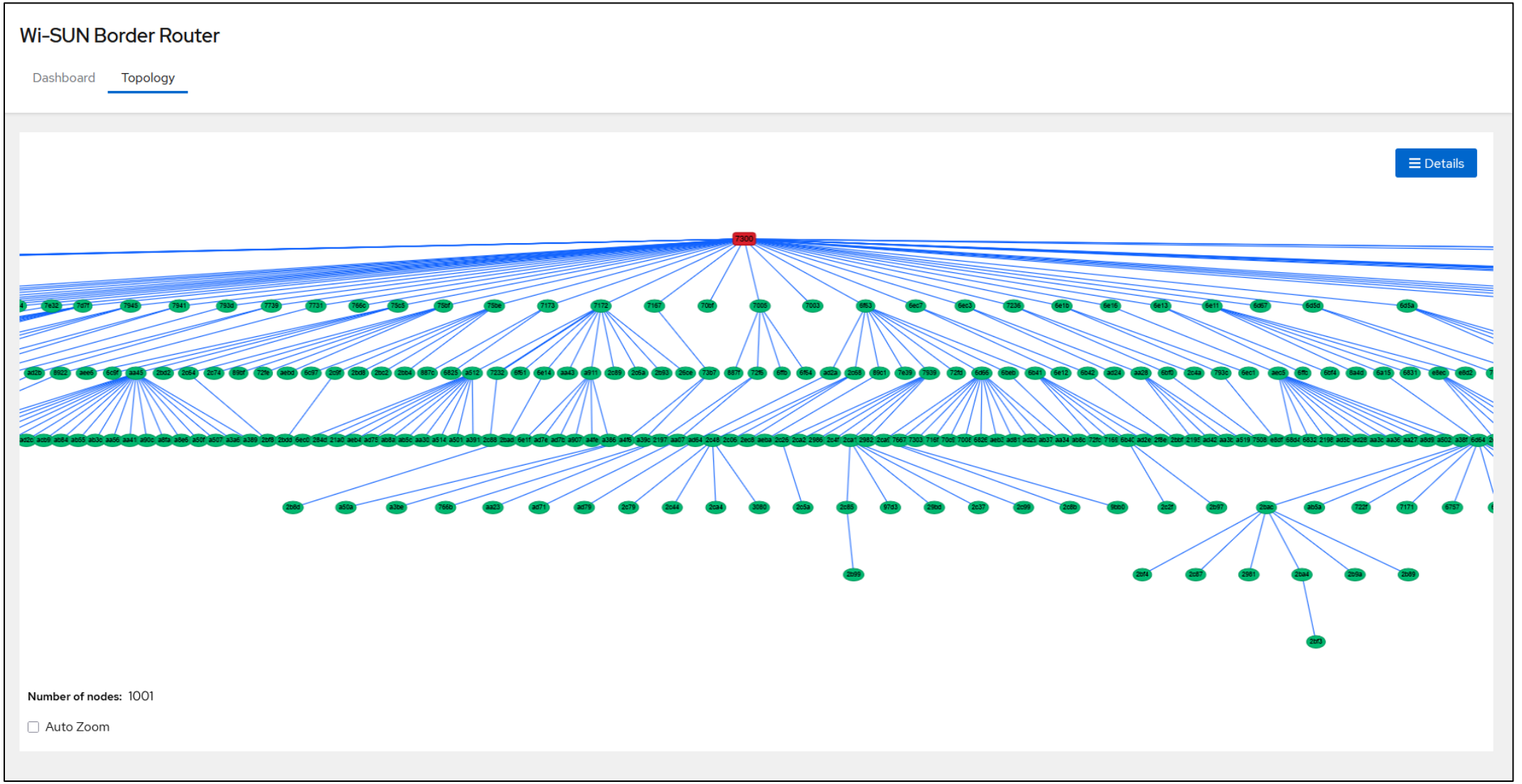


Monitoring

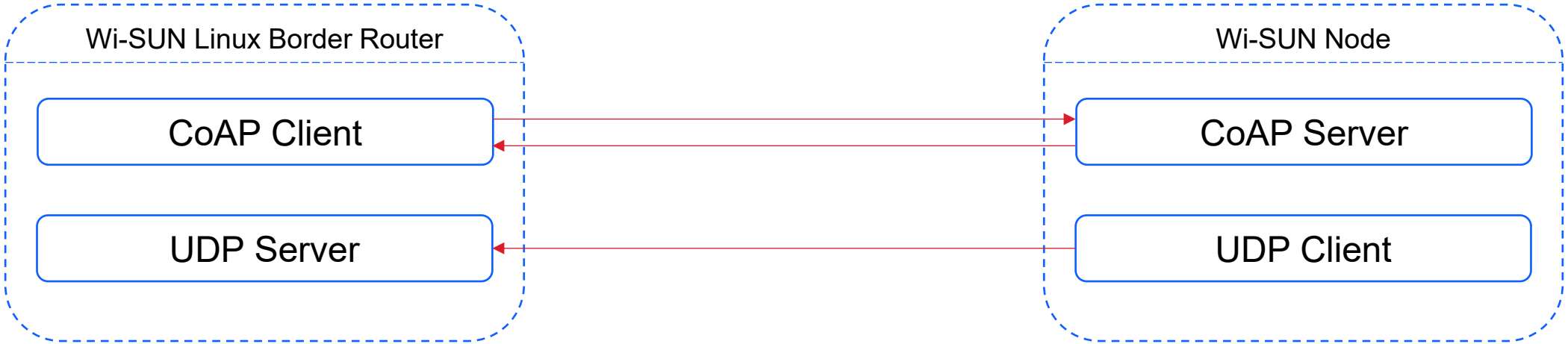
Wi-SUN BR GUI


Wi-SUN Border Router
Dashboard
Topology
Details
Number of nodes: 1001
Auto Zoom

Wi-SUN BR GUI



Node Monitoring Application

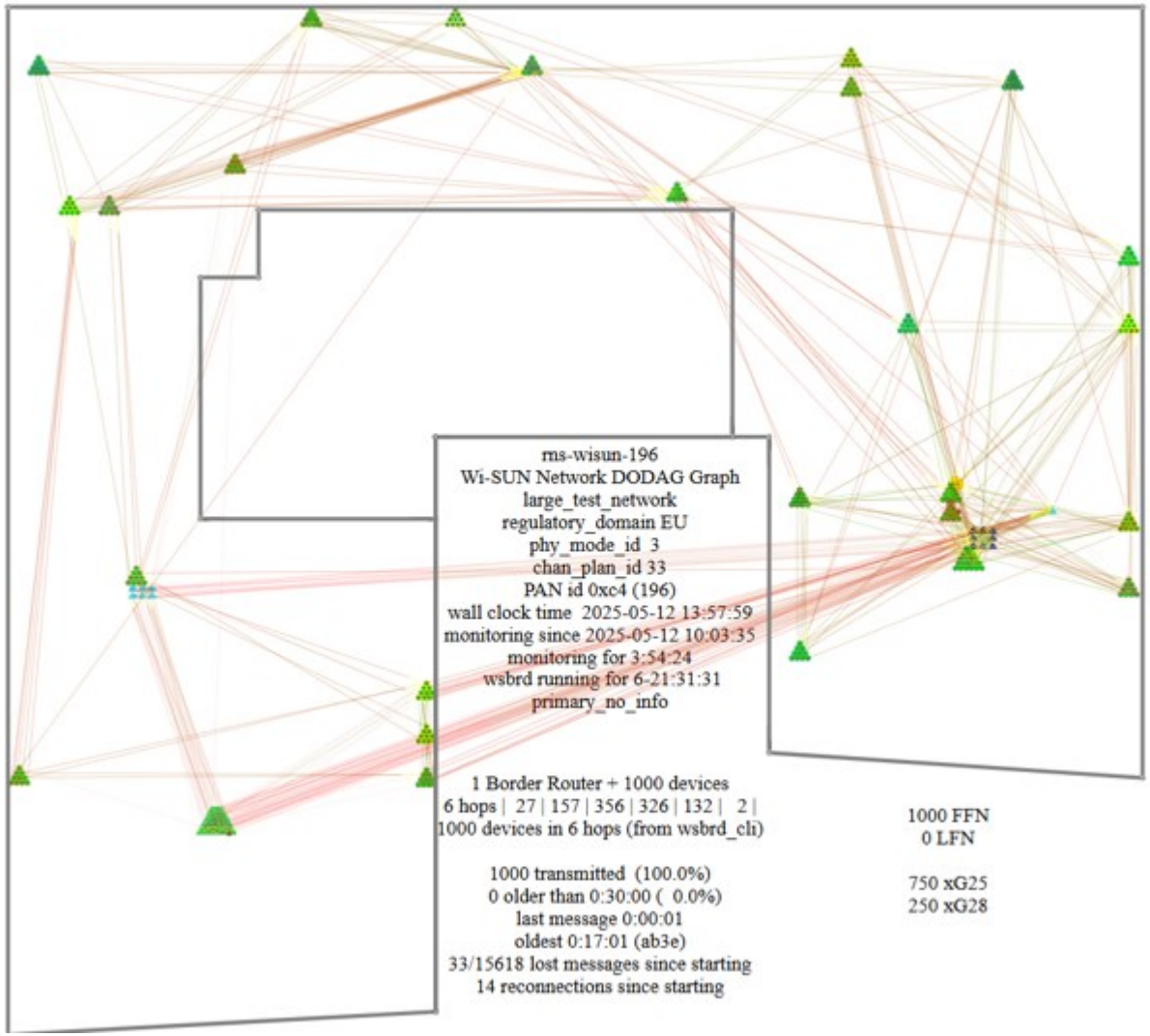


- **On-demand Info and configuration**
  - Getters allowing
    - To pull all the statistics gathered by the node
    - Device Information
    - Device Status
  - Setters to change the configuration of the device if needed

- **Automatic Status Message**

- "ipv6":fd12:3456::2adb:a7ff:fe77:2ec8"
- "device":"2ec8"
- "chip": "xG28",
- "type":"FFN with No LFN support",
- "MAC":"28:DB:A7:FF:FE:77:2E:C8",
- "parent":"2c38",
- "rpl_rank":"915",
- "etx":"141",
- "routing_cost":"0",
- "rsl_in":"96",
- "rsl_out":"96",
- "secondary":"2ca1",
- "sec_rsl_in":"99",
- "sec_rsl_out":"99",
- "running": "6-02:02:18",
- "msg_count":"586",
- "heap_used":"51.00",
- "connected": "0-01:59:36",
- "disconnected":"no",
- "connections": "2",
- "availability":" 99.98",
- "connected_total": "6-01:43:15",
- "disconnected_total":"0-00:01:46",

Visualization of the Office Large Network



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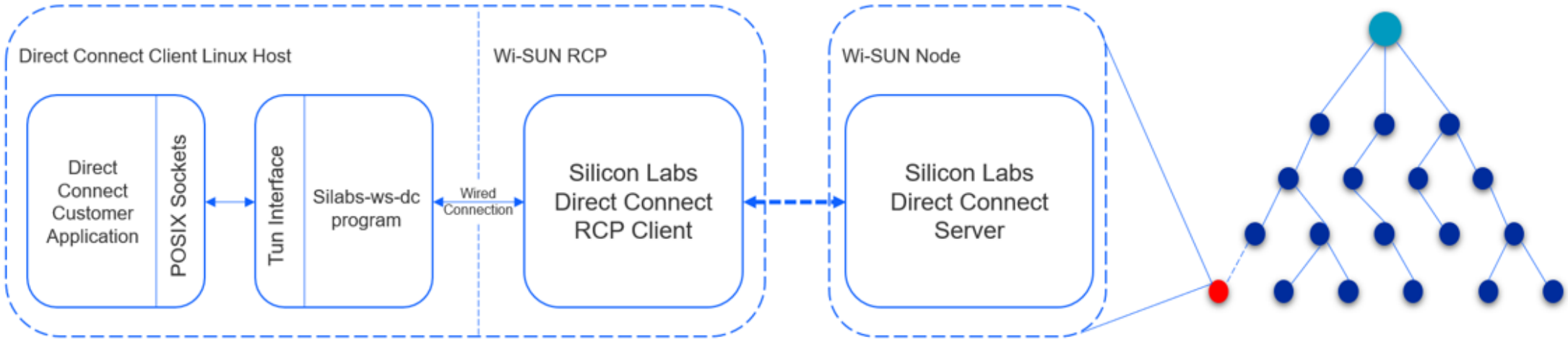
Wi-SUN Direct CONNECT



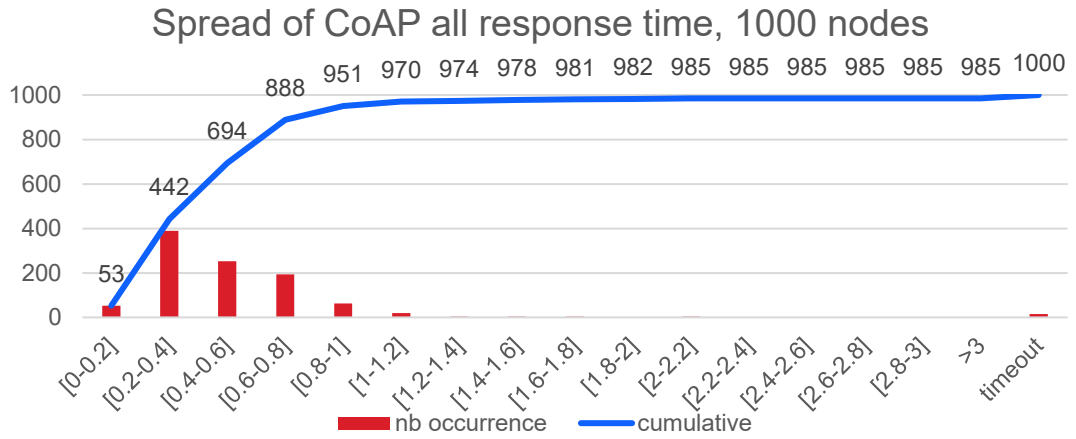
- **Wi-SUN Independent**
- **Trusted and encrypted link using a preconfigured PMK**
- **Seamless connection using the node MAC address**

- **Useful for node debugging when they encounter connection issues to the Wi-SUN Network**
- **Can be used to configure the nodes**
- **Provides a socket interface that leaves a wide room for application customization**
- **A very powerful tool for deployment and network maintenance**

Performance Results

Wi-SUN Latency performance

- **Test :**
  - CoAP request to all nodes, while they are keeping their usual upstream traffic
  - Response time measured for each node



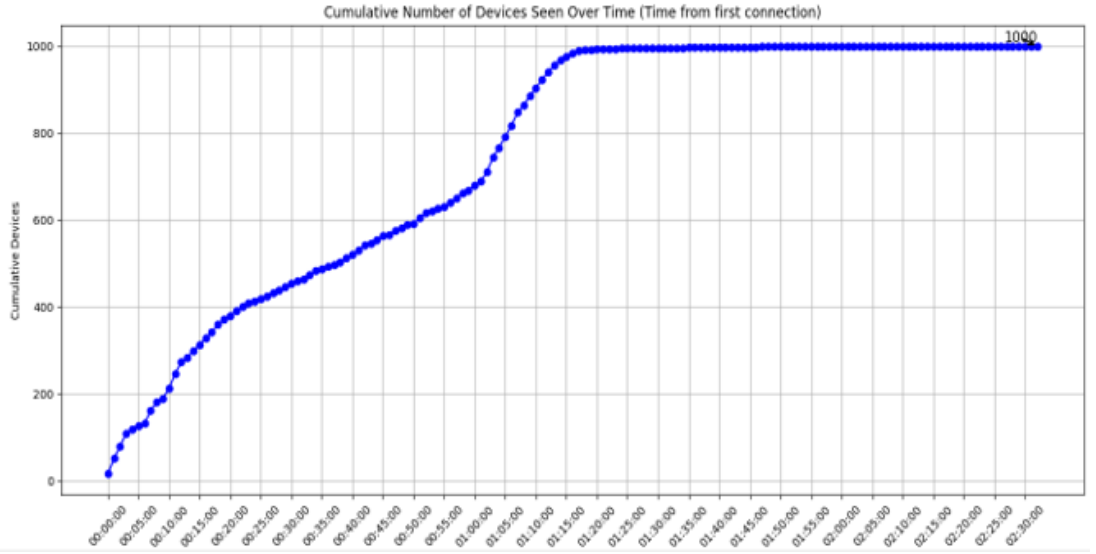
- **Results:**

parameter	450 nodes (hops 1 to 4)	1000 nodes (hops 1 to 7)	comments
Average response time (sec)	0.33	0.49	
Max response time (sec)	0.89	2.07	
Response time < 1sec	100%	95%	
Missing response (sec)	0%	1.5%	Response provided on 2nd request
Total time	149 sec (~2.5 minutes)	498 sec (~8.3 minutes)	Includes 2nd request for missing nodes
Notes	Done before network upscale to 1000 nodes	See graph beside	

Wi-SUN self healing: Full network recovery

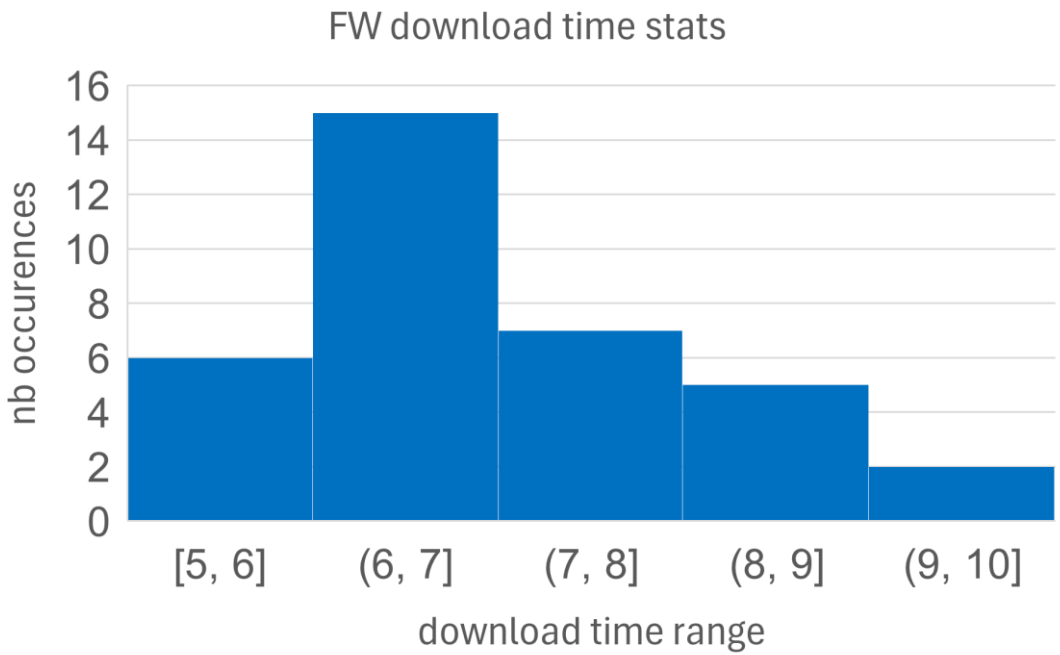
- **Test :**
  - Power cycle on Border Router and all (1000) nodes

- **Results**
  - The graph beside shows the number of devices reconnected over time
  - 900 (90%) devices reconnected in 70 minutes
  - 990 (99%) devices reconnected in 77 minutes



Wi-SUN OTA firmware delivery

- **Test :**
  - 393 kByte FW download in 393 chunks of 1024 Bytes (compressed image)
  - Unicast delivery using OTA component in SDK, with TFTP timeout tuned to 8 seconds
  - Tested on 35 devices (2 to 5 hops from the Border Router) within the 1000 node network
- **Results:**
  - Average download time: 7.45 minutes
  - Maximum download time: 9 minute and 45 sec



Wi-SUN node availability

- **Results**
  - Border Router has been stable and operational for periods **higher than 30 days**
  - Meters availability on the 1000 node network is **above 99%**
  - Nodes uplink messages success rate: **99.8%**
    - Measured on 1000 node network with each node transmitting a message every 15 minutes

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