



TECHNICAL PAPER




INFINITY
controller

Introduction

The Infinity Controller is LigoWave's proprietary element management system that facilitates network installation, configuration, control, maintenance, monitoring, and expansion.

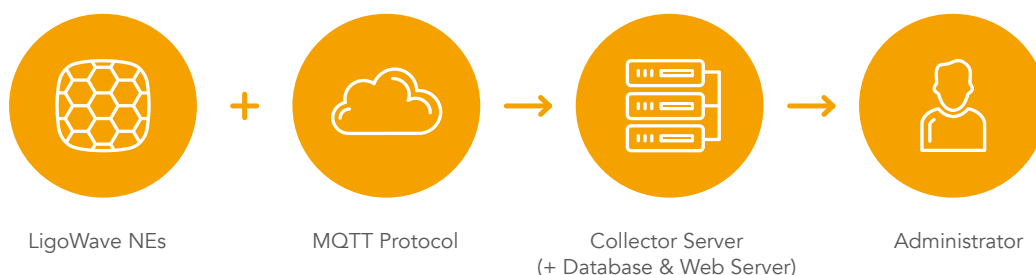
The Infinity Controller is designed to work with all Infinity (NFT), LigoDLB, and LigoPTP NEs. It offers full functionality with the Infinity series, but only supports the monitoring feature on LigoDLB and LigoPTP NEs. The DLB and PTP configuration feature is currently undergoing development.

The screenshot shows the INFINITY controller web interface. The top navigation bar includes the INFINITY controller logo, organization information (FreeCloud, ID: 10122927127318), and user profile icons. The left sidebar contains navigation links: Overview, Networks, Devices, Clients, Maps, Users, Billing, and Hotspot profiles. The main content area is titled 'Networks' and shows a breadcrumb path: Main network LigoW... / DLB test / DLB monitoring. Below this, there are tabs for Info, Clients, and Devices. The 'Devices' tab is active, showing a table of devices. The table has columns for Device, Location, Product, IPv4, LAN MAC, Uptime, Network mode, Operating mode, and Actions. Two devices are listed: AP LigoDLB 5 and CPE LigoDLB 5. Below the table is an 'Add devices' button and a pagination control showing 1 of 1 items.

Device	Location	Product	IPv4	LAN MAC	Uptime	Network mode	Operating mode	Actions
AP LigoDLB 5	Device location	LigoDLB 5	192.168.13.203	00:19:3B:04:9F:36	--	Bridge	Access point	
CPE LigoDLB 5	Device location	LigoDLB 5	192.168.13.216	00:19:3B:04:9F:38	--	Bridge	Station	

Architecture

The Infinity Controller operational architecture is as follows:



LigoWave NEs (Infinity, DLB, or PTP) gathers and processes data from connected client devices. It is then sent to a Data Collector Server using the MQTT Protocol. This server also hosts the database and the web server, which are used for storing device inventory data, config, and stats, and for the user interface respectively. From here, data travels to the administrator to be used as insights into network status, performance, and other metrics.

Operation Modes

The Infinity Controller offers 2 operation modes: Integrated and External.

The External Controller is the most commonly-used application of the Infinity Controller, whereby it is hosted on a Linux- or Windows-based server. It can be hosted locally on the user's server or can be migrated to the cloud, which is offered as a service by LigoWave.

The Integrated Controller means that the network is managed by a local device (a LigoWave device acting as the Master AP). This option does not require any additional management hardware or software, but is, however, limited to networks of up to 50 NEs.

Supported NEs

The Infinity Controller is designed to work with all network elements within the Infinity, LigoDLB, and LigoPTP series, supporting up to 10,000 registered NEs at once.

Controller & Firmware Versions

As of July 17th, the Infinity Controller is in version 1.11. The Cloud Controller is updated as soon as a new version is rolled out. However, those using the local External or the Integrated Controller must perform the update manually.

The External Controller offers a centralized NEs firmware update feature that allows users to install the latest firmware onto all or individual devices or whole networks from the controller's UI.

Users have several options for installing firmware:

1. They can set the Infinity Controller to download and apply the latest firmware image as soon as it is rolled out.
2. They can download the firmware manually and schedule it for updating on either all or specific devices and/or entire networks at set time(s).
3. They can download the firmware and update devices and/or whole networks manually.

Third-Party Solutions

The Infinity Controller supports a number of third-party analytics and guest Wi-Fi, Wi-Fi management, and hotspot solutions provided by LigoWave's technological partners. The most current list of technological partners can be found on the LigoWave website at <https://www.ligowave.com/technological-partners>.

NFT Firmware Integration into LigoDLB

Infinity firmware can be installed on LigoDLB devices so as to set up an outdoor Wi-Fi hotspot. By loading NFT firmware onto a LigoDLB device, it acquires all of the functions available with the Infinity series, including the Infinity Controller.

Infinity firmware can be installed on the following LigoDLB devices:

- LigoDLB 2 series
- LigoDLB 5 series
- LigoDLB 5 AC series
- LigoDLB PRO 2 series
- LigoDLB PRO 5 series
- LigoDLB PRO 5 AC series

Grouping

The Infinity Controller allows users to categorize devices and networks into groups and subgroups based on their location, ownership, purpose, or other custom categories with up to 4 grouping levels.

L2/L3 Subnetwork Segmentation

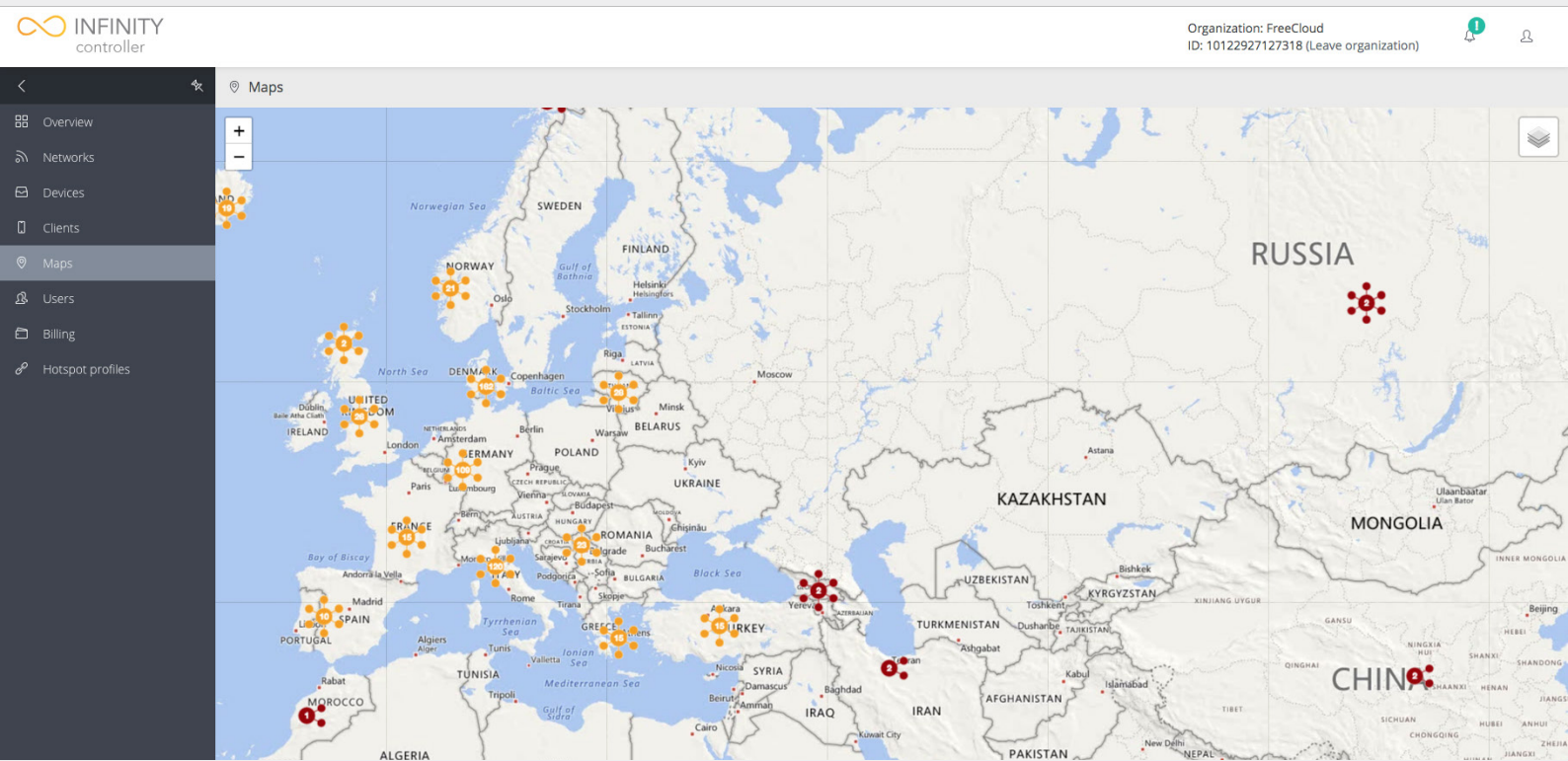
The Infinity Controller lets users manage devices on both Layer 2 and Layer 3 network levels and to segment them so as to apply different configurations.

Map Services Support

The Infinity Controller allows users to view their devices on a map provided by a map service for monitoring and management purposes. At the moment, the controller supports Bing Maps and Google Maps.

Geolocation

The Infinity Controller is equipped with a geolocation feature whereby it scans all nearby network devices and compares this information with a Google server to pinpoint its location in the world.



Operations Support Systems

The Infinity Controller is compatible with service provider operations support systems (OSS) used for managing networks.

Application Programming Interface (API)

Users can set up the Infinity Controller to gather device statistics on Wi-Fi user behavior. The Infinity Controller itself stores up to 2 days of historical data. This data can be imported into proprietary or third-party applications for analytics and insights. An API Key is freely available to users upon request.

UPCOMING: Northbound Interface (NBI)

LigoWave is currently working on developing an SNMP-based northbound interface to communicate data and functions with upper-level layers within a user's network architecture.

Automatic Device Registration

The Infinity Controller comes with a set of automatic device registration methods that simplify network installation and expansion.

- DHCP Option 43, a method whereby clients and servers exchange vendor-specific information and register any identified LigoWave devices.
- Automated Device Onboarding, a method whereby new devices are automatically identified and registered through an existing manually-configured device in a given L2 network.
- MAC Address Preloading, a method whereby the user manually inputs device MAC addresses into the controller, which are automatically integrated into the network as soon as they become available.

Security

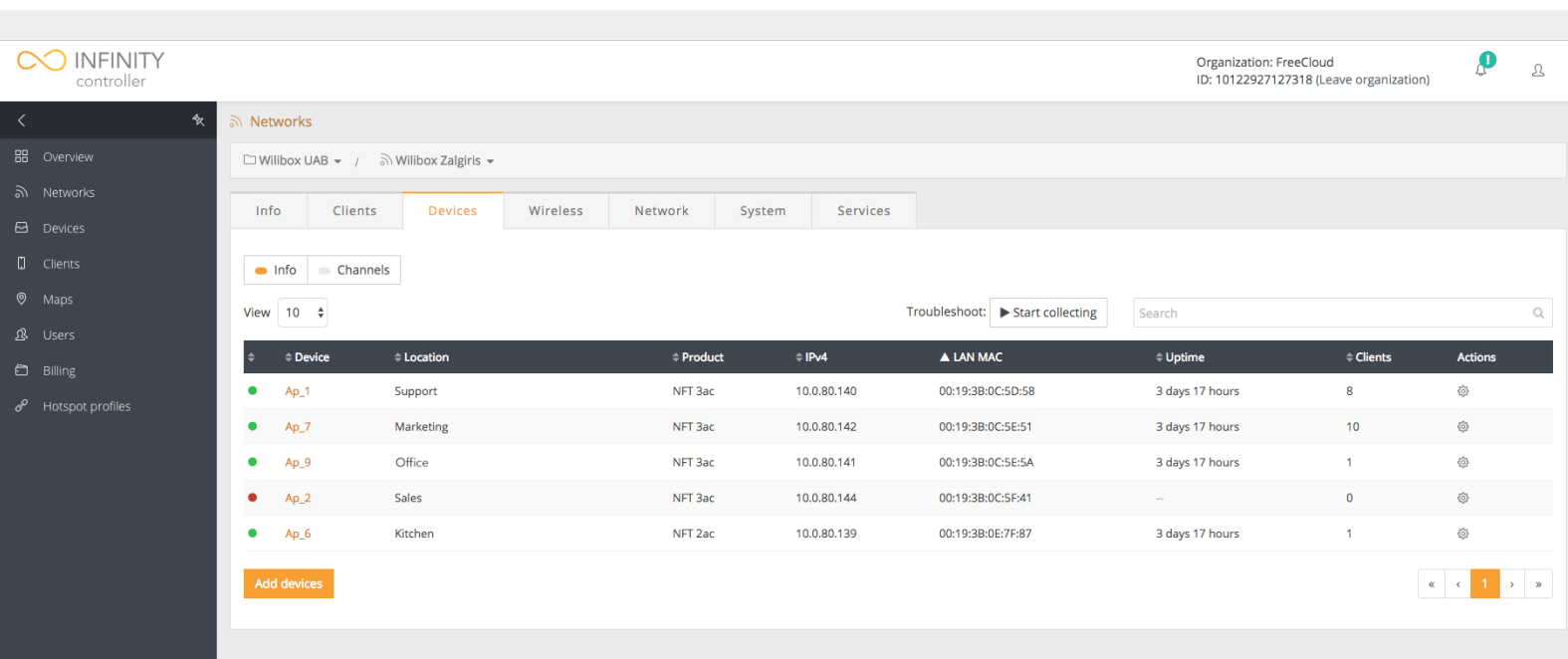
The Infinity Controller offers several security measures:

- Users can be assigned one of three different permission levels: admin/owner, manager, and read-only user.
- The communication between LigoWave devices and the collector server uses a TLSv1-encrypted MQTT protocol.
- The Infinity Controller's user interface is built on HTTPS with official certificates.

LigoWave is also currently developing alarms, a new security feature that will notify the user of network activity, whether suspicious or general.

Troubleshooting

Users can get troubleshooting files containing logs, statistical counters, configuration, and status of a specific device. These users can download the file through the device's UI as well as through the Infinity Controller, if the user needs troubleshooting files of all devices within the network.



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Device	Location	Product	IPv4	LAN MAC	Uptime	Clients	Actions
Ap_1	Support	NFT 3ac	10.0.80.140	00:19:3B:0C:5D:58	3 days 17 hours	8	[Settings]
Ap_7	Marketing	NFT 3ac	10.0.80.142	00:19:3B:0C:5E:51	3 days 17 hours	10	[Settings]
Ap_9	Office	NFT 3ac	10.0.80.141	00:19:3B:0C:5E:5A	3 days 17 hours	1	[Settings]
Ap_2	Sales	NFT 3ac	10.0.80.144	00:19:3B:0C:5F:41	---	0	[Settings]
Ap_6	Kitchen	NFT 2ac	10.0.80.139	00:19:3B:0E:7F:87	3 days 17 hours	1	[Settings]

Roaming

The Infinity Controller can configure the devices for Wi-Fi operation with roaming. This is possible by setting the Mini Hotspot preconfigured scenario, whereby one node is used as an authentication point (gateway), while all other connected APs operate through the node.

User/Admin Authentication & Management

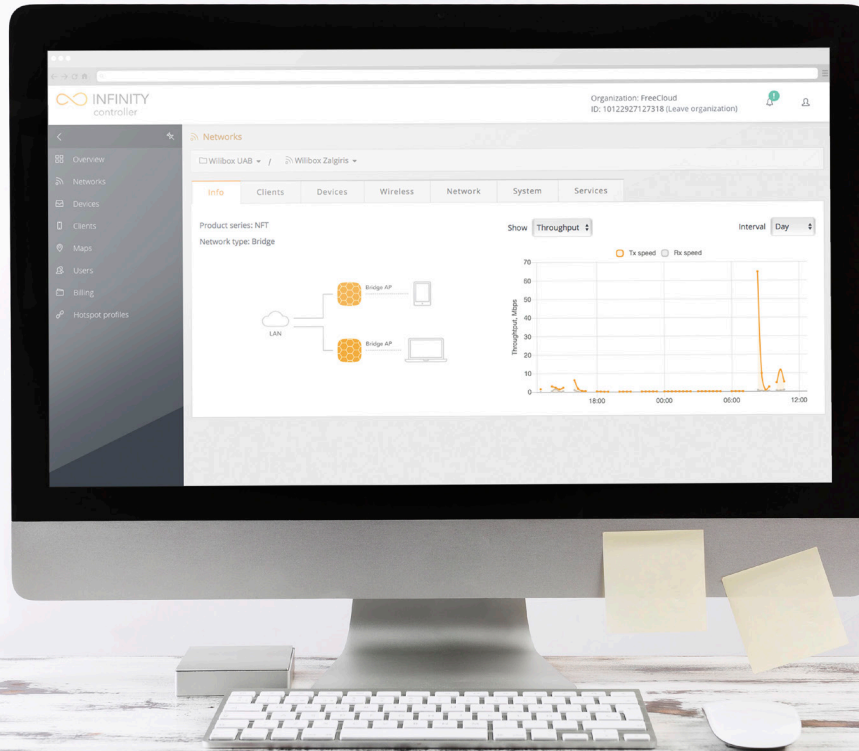
The Infinity Controller provides three types of local accounts: administrator, network manager, and monitor (read-only) user (ordered from most permissions to least).

Client Authentication Options & Features

The Infinity Controller supports WPA/WPA2-PSK, WPA/WPA2 Enterprise, and web-based authentication (UAM). The WPA/WPA2 Enterprise and UAM options require a RADIUS server. Users can also make use of the wireless access list, which filters clients based on their MAC addresses.

RF Resource (Frequency Channel) Management Feature

The Infinity Controller supports 2 methods of channel selection: [1] whereby an algorithm is implemented in the controller to select the channel, and [2] whereby the device selects the channel. These two methods perform channel selection automatically, but users also have the option to select the channels manually.



Other Functionality & Specifications



Office AP Scenario

- Regular AP Bridge
- SSID with WPA-PSK or WPA-Enterprise
- Many APs in Multi Sites



Proximity

- Integrated Mobile Device Detection
- MAC Address/Time Logged without Any User Interaction
- Real-Time Data Used to Enhance Services



Easy Mesh Scenario

- Very Fast Installation
- Useful in Locations without Wired Infrastructure
- Any AP Can Create a Simple Mesh Network (Including DLB Models)
- Redundancy: Multiple Mesh APs Supported

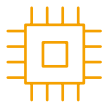


Mini Hotspot Scenario

- One NFT AP Set as Gateway with UAM Running
- Multiple APs in the Same Network Support
- Centralized Web Authentication
- Easy Roaming
- Recommended up to 500 Simultaneous User Sessions

Scalability

- Simple Expansion & Replacement
- Zero-Touch Configuration
- Smart Auto-Provisioning and Auto-Discovery Mechanism



Hardware

External Controller

- Linux, Windows, or MAC OS
- Minimum Hardware Requirements:
 - CPU: Intel i5 (2.5+GHz, Dual or Quad-Core)
 - RAM: 10GB
 - Storage: 40GB
- Recommended parameters
 - CPU: 16-Core 3.6GHZ
 - RAM: 64GB
 - Storage: 500GB SSD

- System Virtualized on Docker Container
- Easy Database Backup
- Easy Controller Update

Communication Protocols (Device-Controller)

- Encrypted Communication Channel (TLS v1) for Management Traffic
- Management Options:
 - HTTP/HTTPS
 - IP/URL
 - SSH



LigoWave

www.ligowave.com