White Paper

Visualize Your Networks with AI-Driven EnGenius Cloud

Rev. 2.4

This article demonstrates how EnGenius Cloud achieves reliable and scalable cloud infrastructure and its unique features to help IT managers better visualize their networks with important insights.

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Introduction

The cloud-managed network model has gained widespread acceptance in the enterprise world. Recent market reports show that Cloud-based Networking deployment will continue to exceed 20% CAGR until 2027. Much of this growth stems from a demand for greater network scalability and agility, especially for distributed branches under a centralized IT infrastructure. This is a common paradigm for small-to-medium businesses in an era of globalization.

On-Premises vs. Cloud

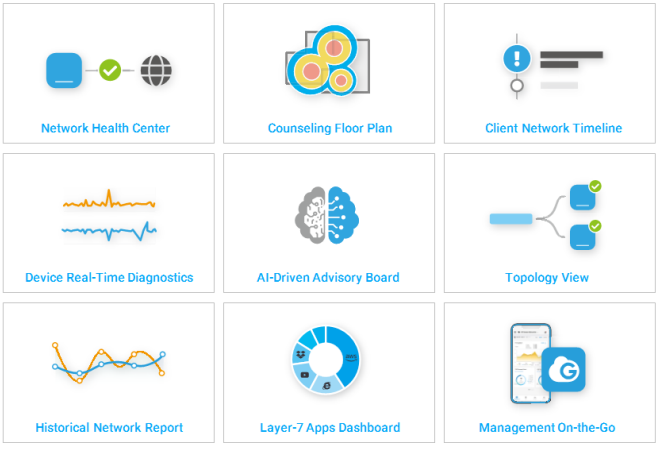
EnGenius has provided an on-premises network management solution for many years. The FitController is the latest version and can be used for local or remote management of switches and Access Points (AP). IT users that want to use an on-premises management solution to keep the management plane in the local network can simply plug in the FitController to a switch port to manage local network Switches and APs. Cloud-based networking has been in more demand in recent years because customers value its simplicity of installing and managing hardware. EnGenius built the EnGenius Cloud based on the latest cloud-computing technology and serverless infrastructure to provide our customers with the most advanced plug-and-play, easy-to-use Cloud solution. IT users can now simply focus on how they want to manage their networks without worrying about server capacity, performance, and scalability.

On-Premises	Cloud
EnGenius FitController Solution	EnGenius Cloud

Figure 1 - *EnGenius On-Premise and Cloud Solution*

AI-Driven Network Visualization

In accordance with the EnGenius corporate philosophy of making simple and easy-to-use solutions, we aim to provide customers with “meaningful” information instead of overcomplicated, cold technical terms. We strive to provide customers with meaningful advice based on AI-driven analytics and reduce customer pain points with tools for easier planning, deploying, and managing. EnGenius Cloud brings networking management to the next level, allowing users to visualize how well the network is performing and provide advice on what could go wrong and where to fix it. EnGenius has also built a fully scalable Serverless platform to reduce downtime dramatically while simultaneously keeping data secure.



Serverless Cloud Infrastructure for High Resilience and Scalability

Docker-Based First-Generation Cloud - Not a true Cloud

EnGenius' involvement in cloud technology development began many years ago when customers started to demand cloud services with zero-deployment options. EnGenius listened to the needs of its customers and, in response, built its first generation cloud solution, a customized instance of ezMaster manager based on the EnGenius Controller, onto cloud-based Docker containers and created a Docker manager to facilitate resource allocation. The server or Docker-based cloud approach is now common practice for many cloud solution vendors. However, we discovered a number of issues after performing a variety of stress tests.

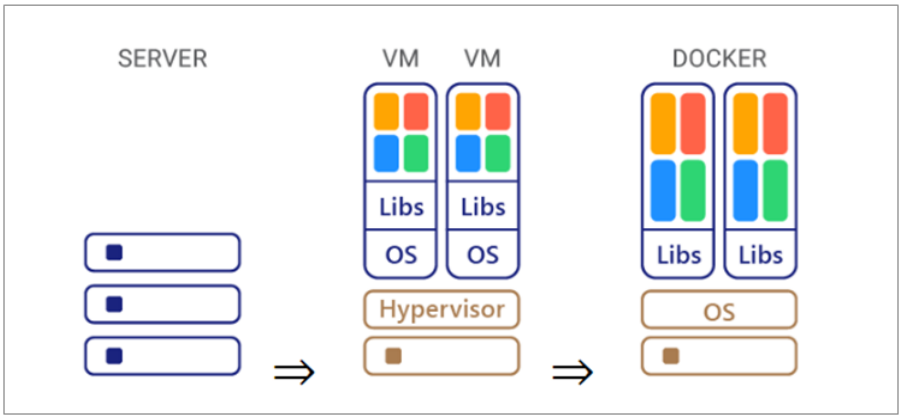


Figure 2 - *Server vs. Virtual Machine vs. Docker*

Note:

Server-Based Cloud - physical machines placed in cloud data centers with specific central processing units (CPU), memory, etc., similar to traditional infrastructure as a service (IaaS) features.

Virtual Machine-Based Cloud - There is no physical machine limit, but the virtual machine (VM) still requires a specific CPU and memory space to install the

operating system (OS) and bins/libs to run the application. VM leverages hypervisors to manage physical servers underneath.

Docker-Based Cloud - Docker runs on the same OS for smaller services to benefit from sharing OS resources, but each container contains its binaries and directories. Docker container manager is usually used to manage the container lifecycle and scaling.

Not a True Cloud

Cloud services should be able to handle both large and small needs anytime, anywhere. Likewise, the Cloud Network Manager should be able to handle hundreds of thousands of devices in a scalable way and provide always-on service with a design built for resiliency and disaster recovery.

In the Docker-based first-generation cloud infrastructure, we found the following common issues:

- Inadequate data protection
- Cannot scale and requires manual adjustment
- Cannot plug-and-play and requires port settings on the firewall
- Limitation on the number of managed nodes per site
- Poor performance when the capacity limit is reached

Customers would be initially unaware of these issues as the cloud operation team could manage problems by closely monitoring the capacity, fine-tuning the size, or rebuilding the Docker container if necessary. In the long run, however, this might result in downtime caused by machine performance issues or human error and wasted resources and time. To make a more intelligent and simpler solution, EnGenius decided to migrate to a next-generation cloud architecture design to ensure a more sustainable level of quality for EnGenius services to customers. However, many cloud deployments are similar to our 1st generation cloud deployment, where companies (vendors) created a Controller image for a Cloud VM to their Cloud solution. With that deployment, it will be difficult and complicated to move devices across the different organizations, move the licenses, have several tiers of administration across regions, and it will have many limitations to managing multi-tenants, especially for managed service provider (MSP) deployments.

Next-Generation Serverless FaaS Cloud

Serverless infrastructures abstract the server components and adjust for scale based on event-driven function requirements. When a new function is requested, appropriate resources are allocated based on the functional characteristics. The serverless design increases the resource utilization rate and improves performance for each function. Therefore, serverless design is referred to as FaaS (Function-as-a-Service) design.

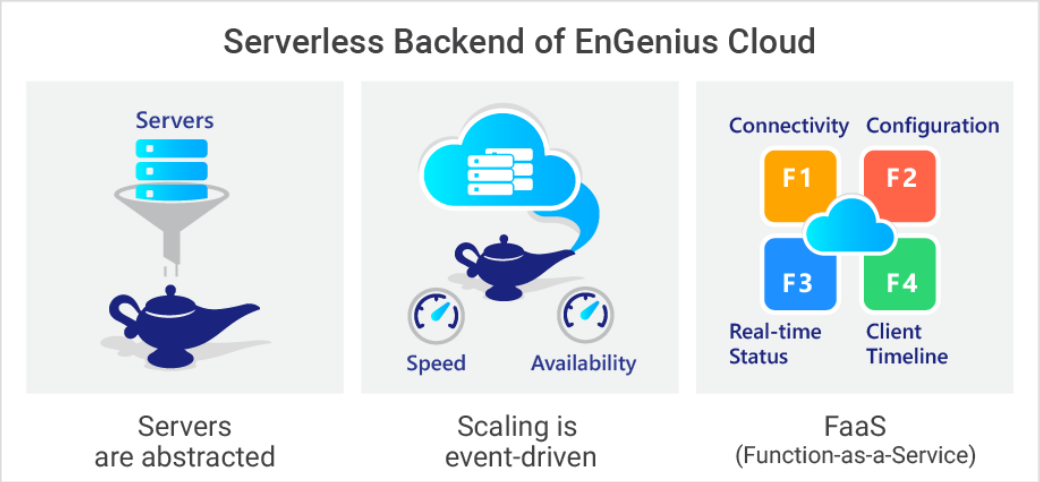
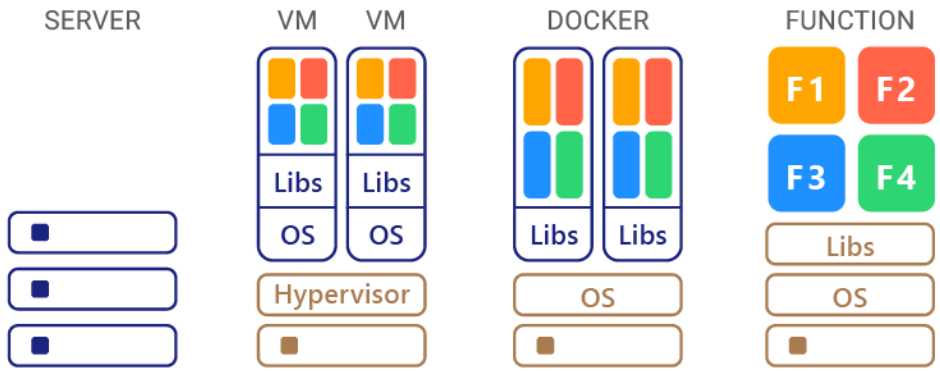


Figure 3- *Serverless Cloud*

Network management has many functions, including hardware device connectivity, configuration, historical dashboard, real-time device utilization status, and notifications. Each function has unique requirements in its backend design for high efficiency. Serverless FaaS architecture dispatches different function requests to different backend service pipelines under an event-triggered base. FaaS doesn't need to consider server/VM/Docker limitations, so the infrastructure is flexible and scalable to adapt to sudden demand spikes that would overwhelm previous architectures. Most importantly, the serverless design allows EnGenius Cloud to streamline the redundancy of components in cloud infrastructure and perform database backup and restoration where the customer's network information is located.

The following table (figure 4) states the different approaches between server-based, VM, Docker container, and FaaS. The scale limitation for the server-based or on-premises server is on the machine's CPU, memory, and

database size. When scaling up, IT users must purchase additional servers and copy all relevant files to the new server, which may take days or months. VM or Docker scalability relies on the physical machines in the data center. IT users need to select appropriate sizes based on the demand that is required. The database's size and application limitations also constrain it. When moving to a different scale environment is required, it will take minutes to days to complete, depending on the flexibility of container management deployment. For FaaS serverless design, all servers are abstracted, and scaling takes mere seconds, increasing ease of scalability and quick reduction of resources when the demand for resources is lower.

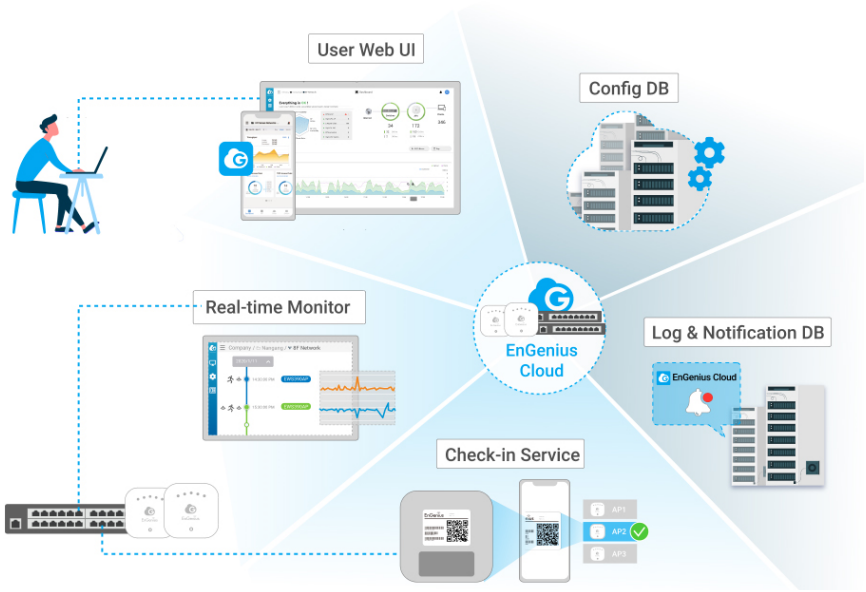


	Server	VM	Docker	FaaS
Scale Boundary	On Premises Machine	Machine	Machine & Application Libs	Function (Micro-Service)
Run Time	Days–Months	Hours–Months	Minutes–Days	Micro-Sec-Seconds
Cost	New Server	Per VM	Per VM	Per Request
Solution	On-Prem FitController	On-Prem FitController on AWS	1st Generation Cloud	Next Generation Cloud

Figure 4- *Comparison between different cloud architecture approaches*

EnGenius divides its controller into 6 key functions. Each function has a unique cloud service design and communication protocol that is tailored to its specific requirements. Additionally, the functional components are designed to scale independently, based on their load, so that the overall EnGenius Cloud remains highly resilient and scalable through the use of the Function-as-a-service (FaaS) design. The 6 function components are:

- User Web UI (User interface)
    - It handles all user web interface
- Check-in Service
    - It handles all device connectivity and communication
- Configuration Database (DB)
    - It stores all configuration of the Networks that users set through User Web UI, then deploys it to the devices through Check-in Service
- Log & Notification DB
    - When the Cloud grows larger, there are a massive amount of logs to store, and at the same time, the Cloud needs to notify hundreds of thousands of users based on their own preference, this requires different database architecture service to handle it
- Real-Time Monitor
    - For Cloud deployment, it will be too costly to keep secure tunnels with all devices, so alternatively, Cloud devices will initiate the link in a short period of time to keep Cloud updated or deploy the newly changed configuration. Then the users will not be able to see “real-time” information such as CPU/Memory loading, real-time client list, and real-time diagnostics information. The Real-time monitor service in the EnGenius Cloud plays a key role in allowing users to view real-time information for all devices that are always connected.
- EnGenius Cloud Engine
    - It plays as an orchestra conductor to glue all services tightly together



Passing Cost-Savings to Our Customers

The other key benefit of Serverless FaaS architecture is cost savings. Research conducted by Libhive and Heavywater back in 2017 already supports the conclusion that moving applications from server-based to serverless architecture can achieve cost savings of up to 90%. EnGenius Cloud has built in-house serverless FaaS infrastructure to provide more efficient cloud infrastructure and return the cost savings in the form of affordable solutions for Enterprise customers.

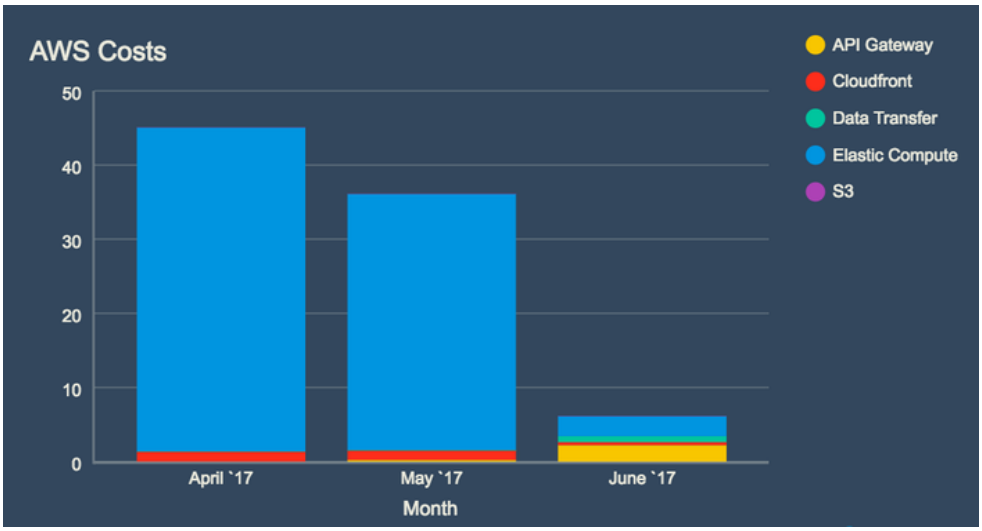


Figure 5- *Cost saving in June after leveraging serverless technology (API gateway in this case) Source: Libhive*

Secure Cloud-Connected Device

Cloud users' data will not go through EnGenius Cloud, ensuring the user has full ownership of their private and sensitive data. EnGenius Cloud only collects Cloud devices' management information for easy user management purposes. In regards to Cloud device security, to make sure only authorized cloud devices can connect, EnGenius Cloud uses TFA (two-factor authentication) to add an extra layer of protection in addition to non-sequential serial numbers and MAC address verification. Every Cloud device has a built-in security key from the manufacturing factory for first-time authentication with Cloud. After a device is authenticated, a secure tunnel is established between the device and the cloud with a unique certificate provided by the EnGenius Cloud to encrypt transmissions. EnGenius Cloud devices will securely transmit data from gateways, switches, and access points and function as normal even if the EnGenius Cloud goes down. IT users will only temporarily lose the ability to change device configuration on the cloud service.

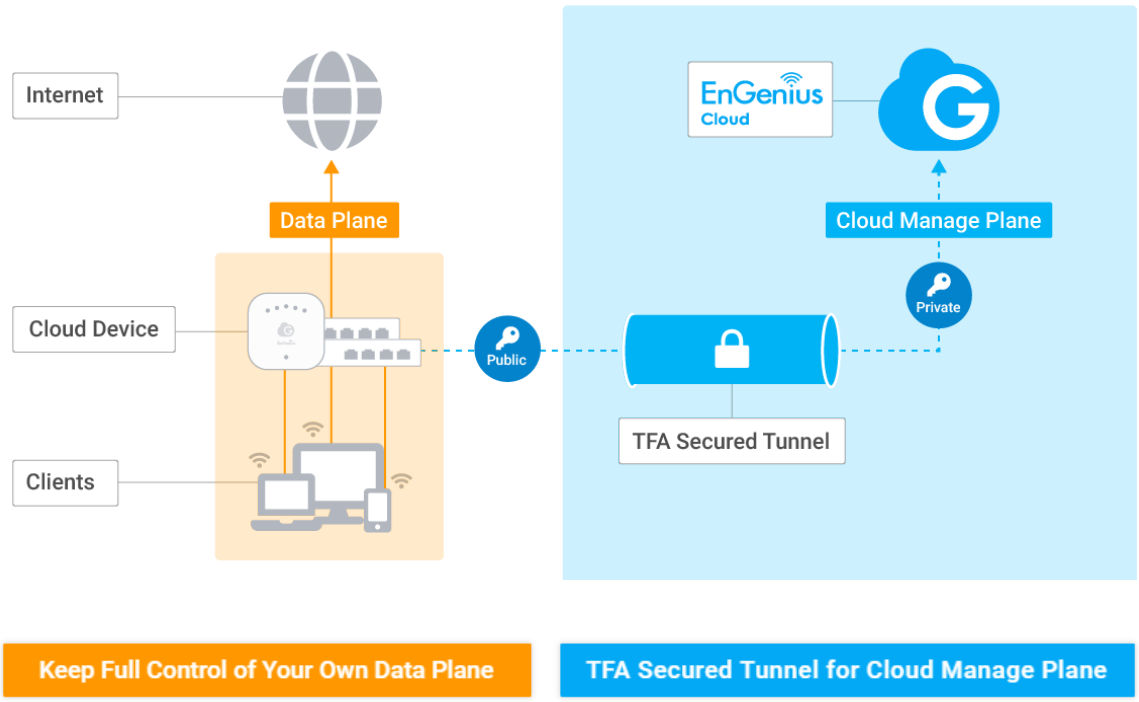
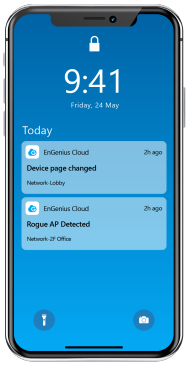


Figure 6 - *Secure tunnel for management plane*

Plug and Play - Easy to Manage Remote Office

For EnGenius Cloud implementations, the headquarters (HQ) network administrator simply needs to configure network settings, register devices by scanning the QR code with the mobile app and assign the registered device to one of the networks on the EnGenius Cloud. The device can be shipped to a branch office, and once plugged in, EnGenius Cloud will push the proper configuration to the device and work as intended.



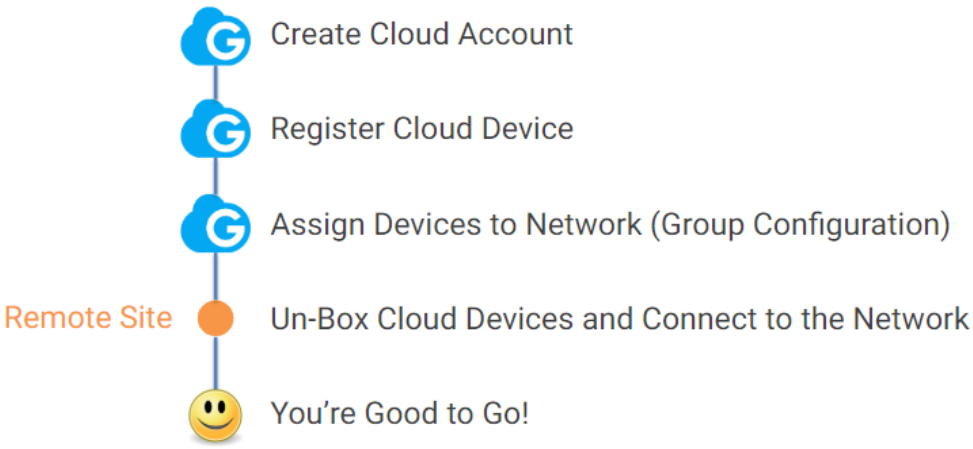


Figure 7 - *Simple steps for Plug-and-Play in EnGenius Cloud Solution*

Reconfigurations and/or professional visits are not required or needed with local failed devices. Any member of a remote branch can locate a failed device, replace it with a new device, and inform the headquarter admin of the newly replaced device's serial number. A replacement device can be plugged in, automatically configured, and work precisely the same as the previous unit.

EnGenius Cloud – Basic Structure

Organization - Network - Hierarchical View

The EnGenius Cloud consists of three essential components: Organization, Network, and Hierarchical View (HV).

- "**Organization**" contains the inventory list of all devices registered within the organization under a single license.
- "**Network**" refers to a group of cloud devices (AP or switch) under the same group configuration.
- "**Hierarchical View**" (HV) Layer: Group of Networks and HV's

In some use cases, a company may have a complex branch network hierarchy, including a combination of central IT management with full access privileges and regional IT teams with grouped network access. In this case, EnGenius Cloud defines the hierarchical view level as a multi-layered group of networks. A Managed Service Provider (MSP) can own a license under the MSP's organization, create a first HV layer for managed-service tenants, and then create additional layers with accounts for tenants to access the tenant HV and networks by themselves. The example below explains how an MSP Company creates a first HV layer for tenants A, B, and C. Under each tenant, there are the US and EU regions, with sub-branch offices under US and EU, so the IT users in the US region of tenant B can only manage for the US region.

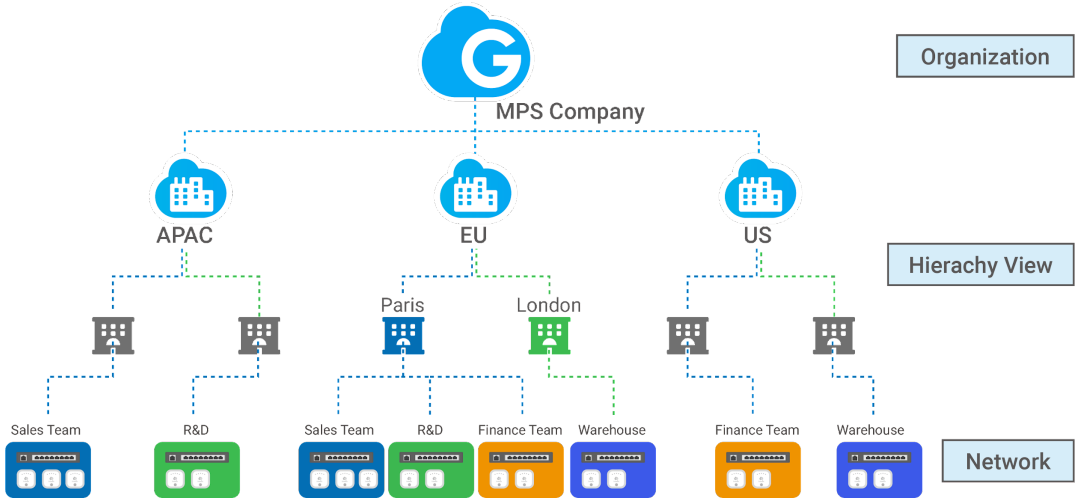


Figure 8 - *Cloud design structure of a multi-tenant MSP company*

Multi-User Privilege

There are two basic user roles: *administrators* with full access privileges and *viewers* with read-only privileges. There are two levels for these roles: Organization and Network:

- Organization Level: has the highest permission in the Cloud and is the only person to manage licenses and complete inventory control.
    - Two administrators are highly recommended to prevent email lockouts
    - Administrator email is recommended to be the same domain as the company domain, so administrator activation and notifications can only be received through the company email server
- Network Level: has the permission to access a specific network and devices under the network.

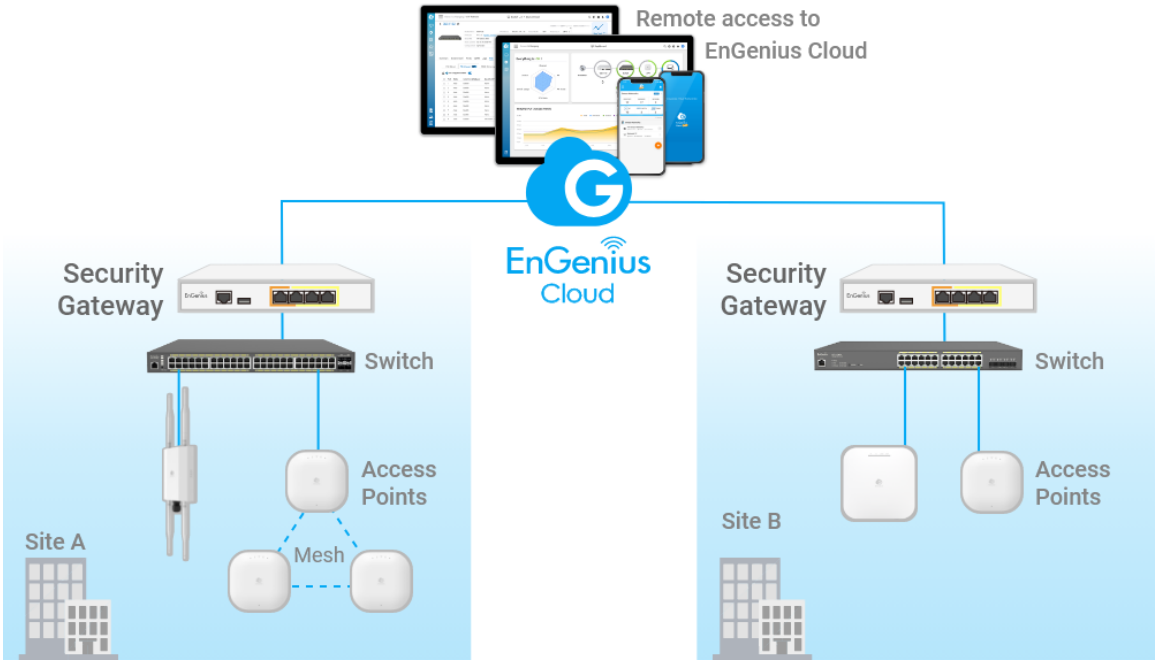
There is no need for separate Hierarchical View privileges since HV is a group of other HV's and networks. All permissions are based on the user's permission to access networks. For example, a user with permission to access finance and R&D can see both the US HV and New York HV, but cannot access the LA HV and Sales networks.

If network support or consultants are required from outside the company, it's recommended to assign network-level permissions only. The organization level has the highest privileges, including the ability to add/remove users and modify license information.

Visualize Your Network

Unify the Network Management from Single-Pane-of-Glass

EnGenius Cloud-managed devices include our SD-WAN Gateways, Switches, and Access Points lines. IT users can manage a whole network from a single pane of glass for a holistic view and to find the issues faster.



AI-Driven Advisory Board

A difficult job for IT administrators is when their users provide limited or vague non-technical descriptions to diagnose technical problems. For example, "I cannot access the Internet" may require different approaches to investigate and resolve the issue. EnGenius Cloud offers IT users visual tools or indicators that assist in resolving problems and potential issues, as illustrated below.

Reference to figure 9. When an AP experiences high channel utilization, it could be related to several issues. Some of those issues could be high wireless data

throughput or other APs attempting to use the same channel, which can cause disruption to the AP beacon or co-channel interference.

The AI-based Advisory Feature will look into the average patterns of the AP to understand if it's an abnormal situation and will give warnings based on those changes. Users can decide to investigate further if the behavior seems suspicious. The Advisory will review other parameters. If there is a beacon disruption issue in the log, it will advise the user to check the floor plan view. The user can then investigate if neighboring AP channels are interfering or direct them to view Spectrum Analysis with a simple one-click quick link. This action will advise the user to change the AP channel to a clear one or identify if there is a rogue AP to disconnect. If the Advisor Feature finds the number of clients in the AP is high, leading to high throughput and memory utilization, the Advisory tool will recommend setting the client limitation lower or checking the client list to identify which client is generating the most traffic.

Figure 9- *AI-Driven Advisor to lead the way to pinpoint real issues*

Client Timeline

Instead of only providing users with the client lists attached to the APs, EnGenius Cloud records each client's journey in the network with timestamps. IT users can use client MAC (media access control) addresses or device names to pull up the entire client history. The Client Timeline includes the AP it connected to, its authentication status, and the time required to roam to another AP. The IT admin

will already be aware of the symptoms and start diagnosing the issue before even speaking to his user.

In the example in Figure 18, the client has associated and authenticated with AP01 but failed to associate with AP02, SSID02. AP02 most likely has seen the device, but the client's transmission power could be too low to accurately send the packets back to the access point.

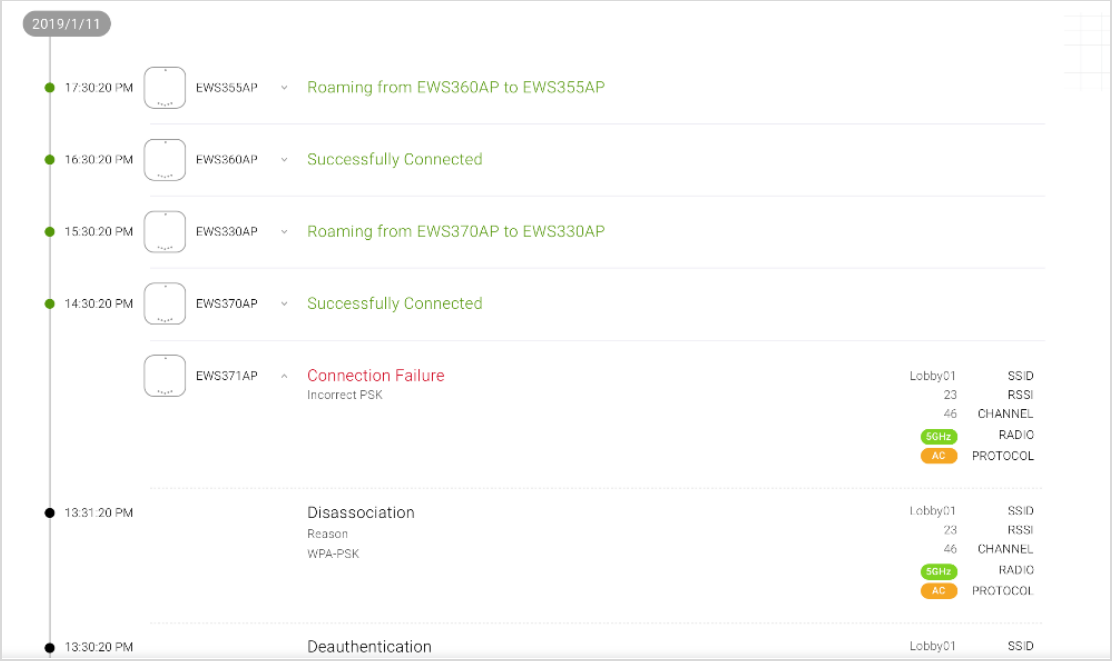


Figure 10- *Client Timeline*

AirGuard WIPS to Protect the Environment from Rogue attack

AirGuard is EnGenius WIPS/WIDS (wireless intrusion and protection system/wireless intrusion and detection system) technology to detect all malicious attacks like Rogue AP, Evil Twin, Man-in-the-middle, and radio frequency (RF) jamming, then, based on the user's policy, automatically prevent the clients from connecting to those rogue APs.

SD-WAN for Secure Connectivity of Branches

Easy Site-to-Site VPN Set-Up using Auto VPN

EnGenius Cloud-managed SD-WAN (software-defined wide area network) gateway allows users to simply click one button and build a Site-to-Site VPN (virtual private network) mesh connections between branch offices and headquarters without any complicated configuration of WAN IP, ports, authorization, and encryption protocol settings.

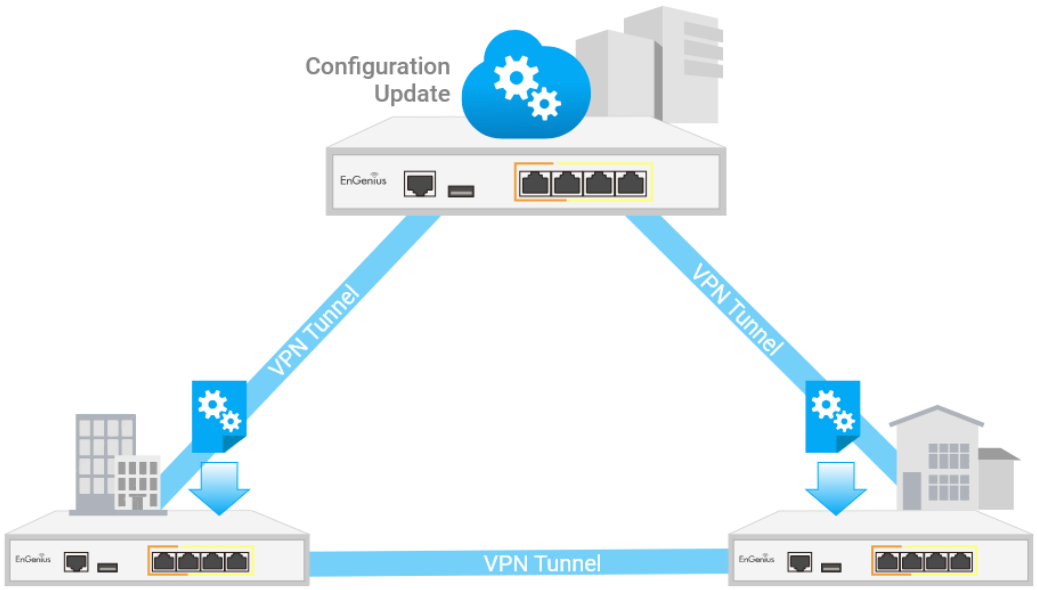
EnGenius Cloud can leverage the gateway information it stores, current WAN IP, and ports to setup, initiate, and maintain a VPN. EnGenius Cloud has a VPN registration center to simplify the VPN setup and maintenance process. The VPN registration center keeps all the necessary information about the gateways and their peers (local and remote) in an organization. EnGenius Cloud can quickly re-establish or fix the VPN connection if it changes or is interrupted.

Self-Healing VPN Topology

Internet service providers (ISP) may occasionally change the Gateway's WAN IP address. If or when the WAN IP is changed, the EnGenius Gateway will notify EnGenius Cloud and it will then notify all VPN-connected peers to change their WAN IP addresses accordingly.

Auto NAT Traversal

It complicates the VPN setup when the gateway resides behind a NAT device. Admins need to set up IP ports to map correctly to build the connection. EnGenius Cloud uses hole-punching technology to force the device to talk to EnGenius Cloud and keep updating the WAN IP/Port to create the VPN connection.



Integrated ezWiFi Planner Completes the Cycle from Design to Result

EnGenius customers have been enjoying the subscription-free benefits of our award-winning ezWiFi Planner tool. This tool can simulate an environment with obstacles to help our customers determine AP placement and radio configurations in their network deployment.

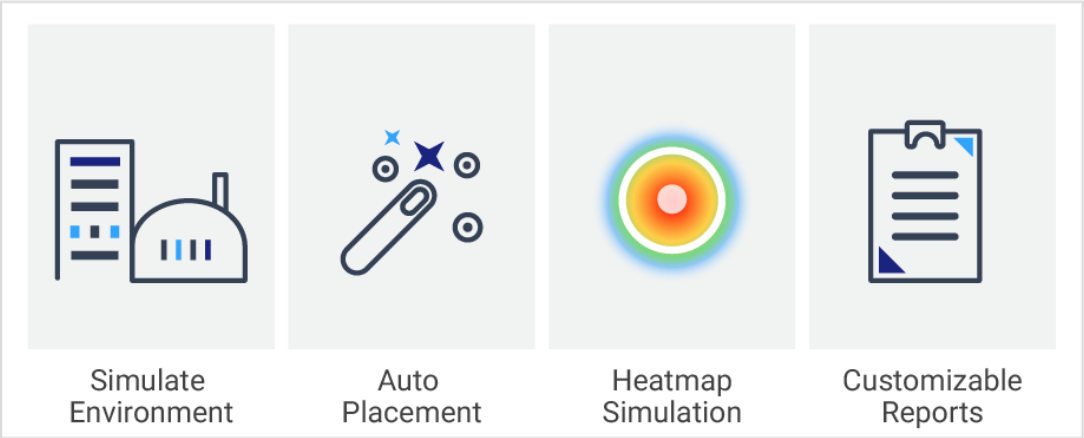


Figure 11 - *Award-winning ezWiFi Planner simulates AP locations to cover required Wi-Fi areas*

EnGenius is proud to announce that the ezWiFi Planner tool has advanced one step further with total integration into EnGenius Cloud. After using the tool to create an initial access point layout, users may now import the floor plans from ezWiFi Planner into the cloud. The virtual access points represented in the plan can be replaced with your real-life access points managed in EnGenius Cloud, where the channel and transmission power of the APs will be applied. Note that the channel and transmission power might be changed from time to time due to auto-channel, auto-RF, or other optimization algorithms.

With the integration, there is no need to spend time redrawing wall obstacles or recreating other elements of your floor plan at a later date. EnGenius Cloud will recompute a heatmap of your layout and coverage with all obstacle interference considerations. EnGenius now completes the entire design cycle of planning, deploying, checking, and adjusting. To plan a Wi-Fi network with ezWiFi Planner,

deploy the Cloud APs based on the plan, double-check the Wi-Fi coverage based on real-life AP parameters, and adjust accordingly.

While heatmaps are a feature available from many other cloud-based vendors, EnGenius Cloud provides a unique offering. Because EnGenius owns both the planner and the cloud platform, it can draw up more accurate real-world conditions in its deployment assessments. Obstacles and congestion areas now play a greater role in predicting a coverage area as accurately as possible. This contrasts with other heatmap software, which makes a naïve assessment of conditions when displaying its AP heatmap.

Figure 12 - *Embedded heatmap tool in EnGenius Cloud*

Some might argue that on-site site surveys should be preferable to developing real-life heatmaps with RF measurement. We agree 100%. There are many potential confounding variables in deployment, such as RF interference from unknown sources, wall thickness, material variation, etc. However, site surveys require competent on-site tools and a thorough examination by a professionally-trained surveyor. This process consumes a lot of time and money.

Furthermore, if the access points are set as auto-channel and auto-RF, the survey results are less useful after transmission power and channel changes because the site survey can only measure Wi-Fi as a real-time snapshot. The EnGenius Cloud Heatmap tool allows you to compute a heat map using the most up-to-date conditions with a single click at no additional effort or cost. The value of this tool is not to replace site surveys, but to enable a more informed decision about whether a full-site survey is justified.

Network Health Check at a Glance

IT users must have constant updates about the status of their network. EnGenius Cloud Dashboard provides a holistic view of the network health, with radar charts to create an overall score based on AP congestion rate, CPU/memory utilization, throughput, and other factors. IT users can also track the number of devices and clients accessing the network and their status.

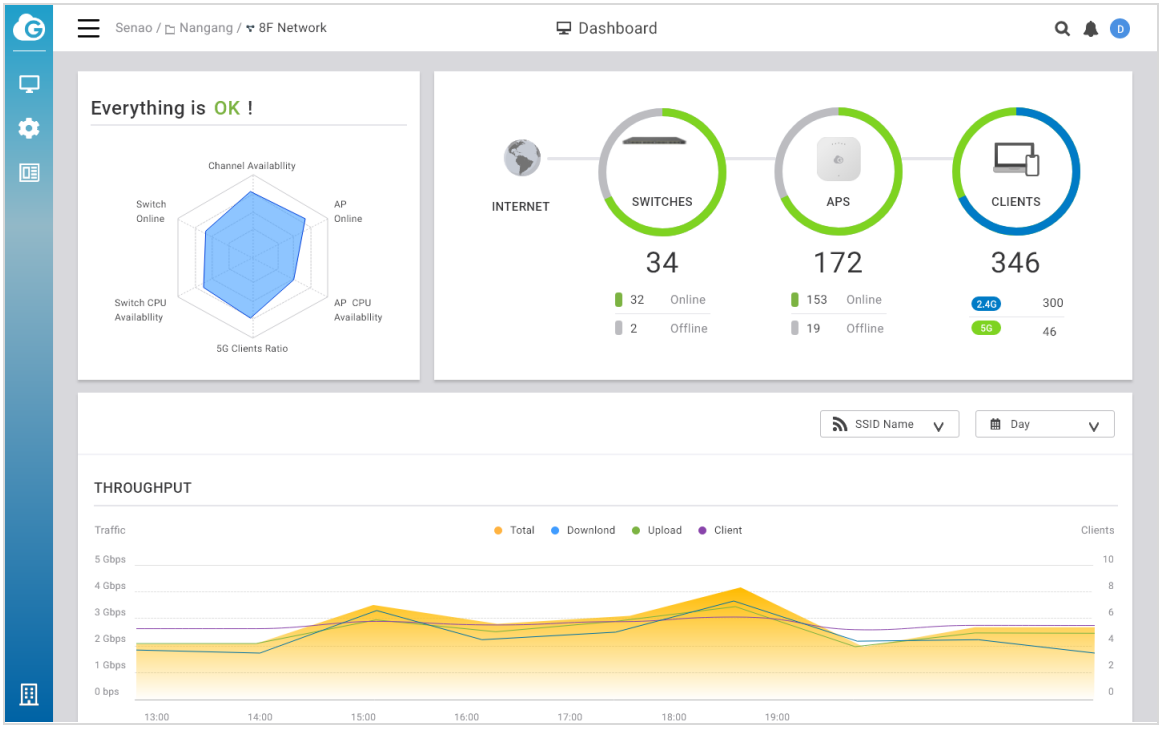


Figure 13 - *Holistic health check view of networks*

When specific devices have a throughput issue, a device list view (figure 14) can help IT managers quickly browse through each device's primary information to pinpoint the problematic device, review device details, and perform troubleshooting if necessary.

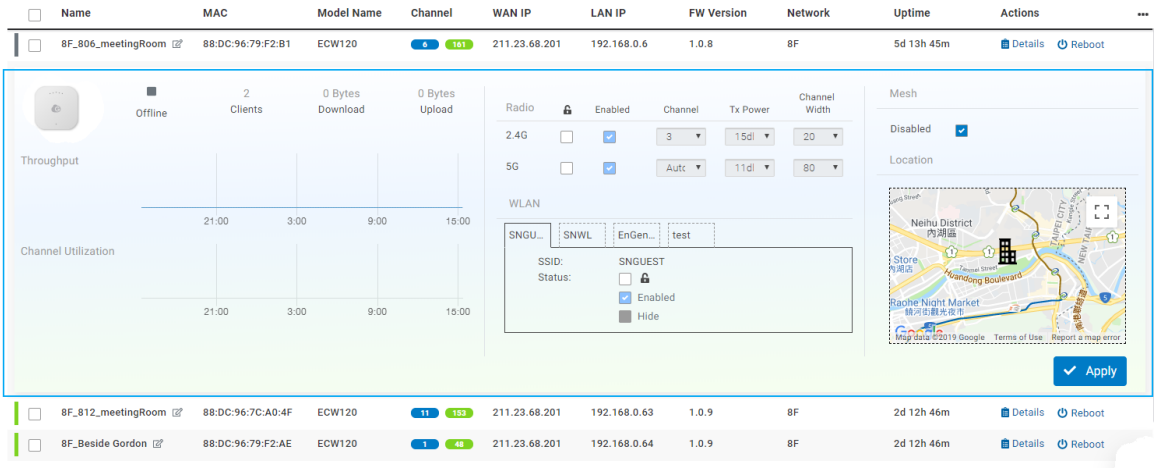


Figure 14- *AP device list view with quick dashboard*

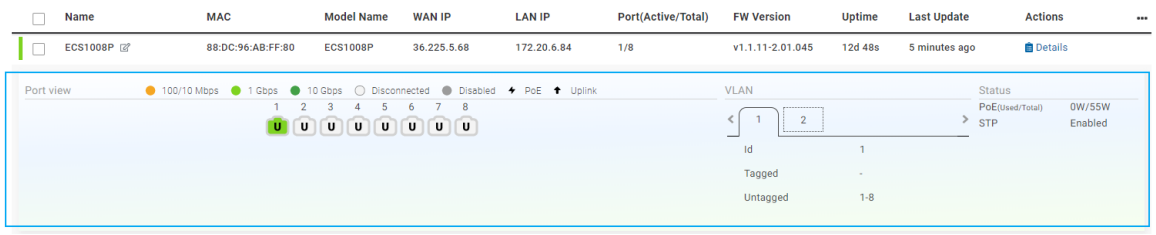


Figure 15- *Switch device list view with quick dashboard*

L7 Traffic Analysis

During periods of heavy traffic, IT users should be able to quickly understand the application source of the traffic increase, such as video streaming applications, peer-to-peer, or web surfing. EnGenius Cloud access points have an embedded Layer 7 DPI (deep packet inspection) engine to collect application traffic information right at the edge, eliminating the need to add an L7 traffic box to collect data and removing a potential speed bottleneck. However, deep packet inspection DPI consumes a lot of CPU power, typically resulting in a 15% decrease in access point performance. EnGenius Cloud allows you to toggle the L7 DPI settings (on by default) via the cloud if increasing performance is a priority.

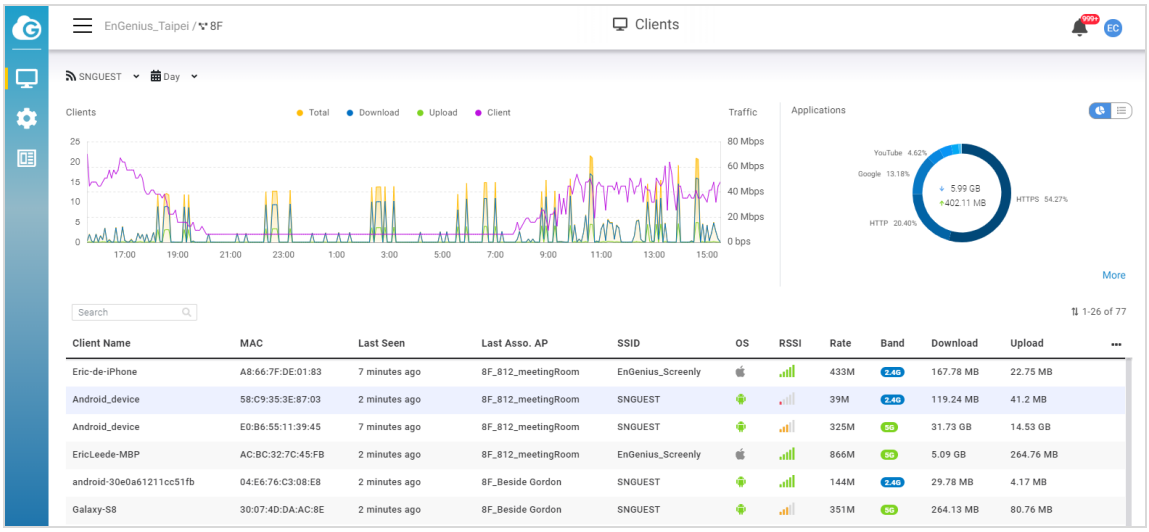


Figure 16 - *Client list view with Layer 7 application-aware traffic dashboard*

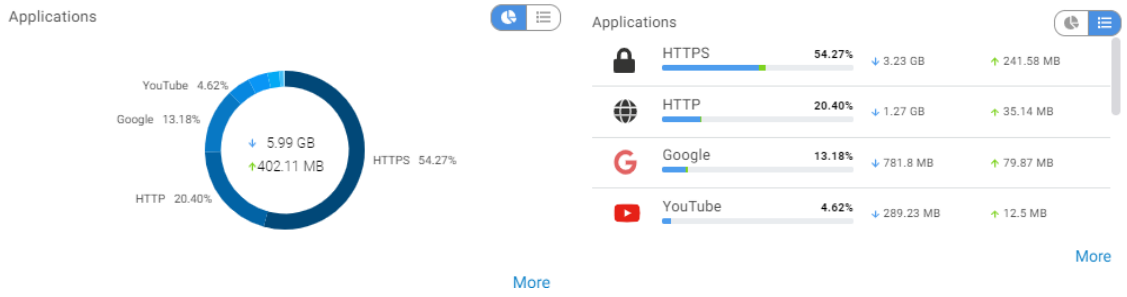


Figure 17 - *Switch device list view with quick dashboard*

Topology View with Speed Test

EnGenius Cloud provides a topology view of any hierarchical view (HV) or network to depict the relation between EnGenius Cloud-managed gateways, switches, and APs in a single overview. IT users can, for example, locate a specific switch and switch port connected to a problematic AP to see if there is an issue with the AP. They can then take action, such as powering the switch PoE port on and off to hard reset the problematic AP.

EnGenius Cloud also provides a tool to test the internet access speed of the device on the topology between the device and EnGenius Cloud, so an IT user can determine if WAN speed or LAN link issues are the sources of the problem.

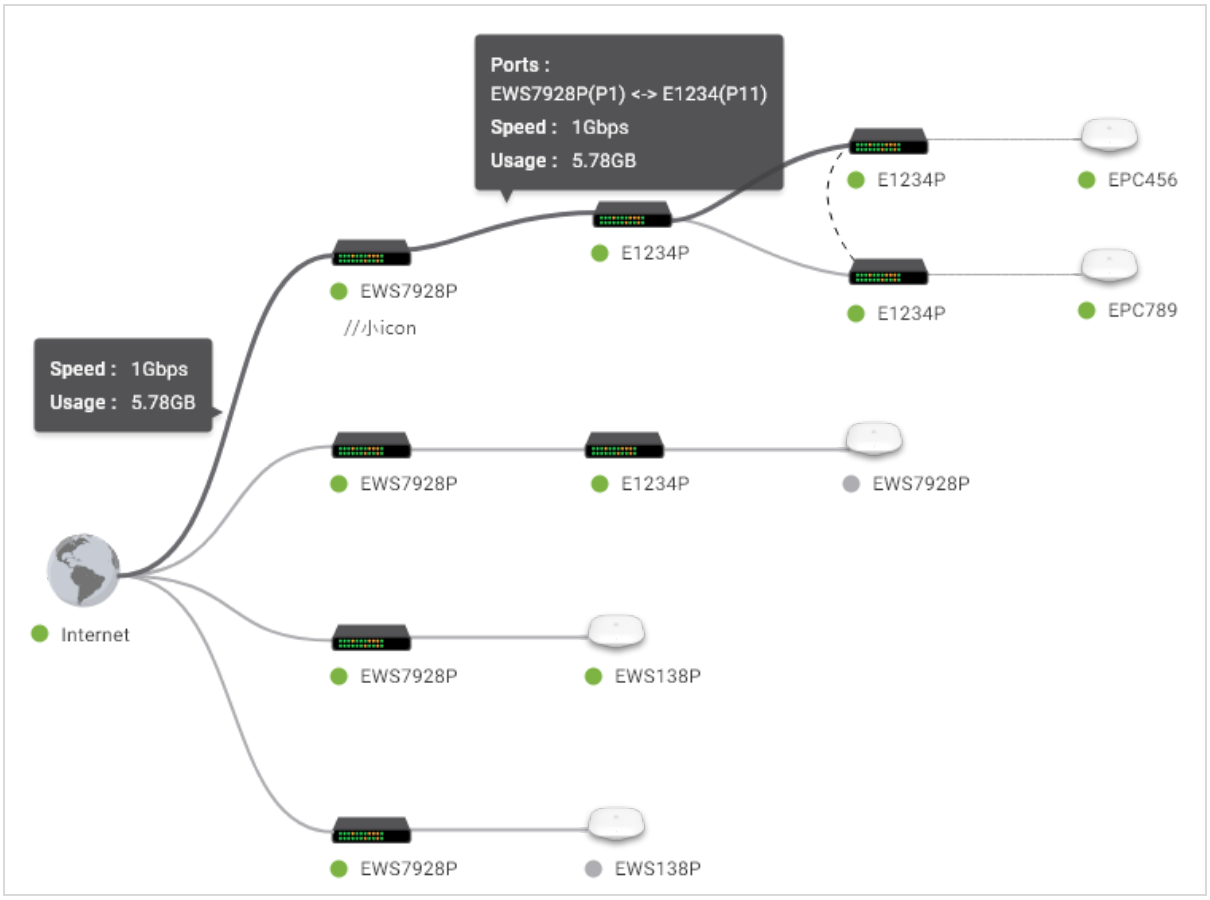


Figure 18 - *Topology View*

Troubleshooting with Insight Visualization

EnGenius Cloud provides many insight visualization features to help IT users rapidly identify issues more effectively than customer Q&A.

Historical Statistics Dashboard

When a specific AP is identified with potential issues, the historical throughput statistics dashboard will help IT users visualize any abnormal traffic patterns degrading the network performance. The Layer 7 traffic dashboard lets IT users see what application takes up the most traffic:

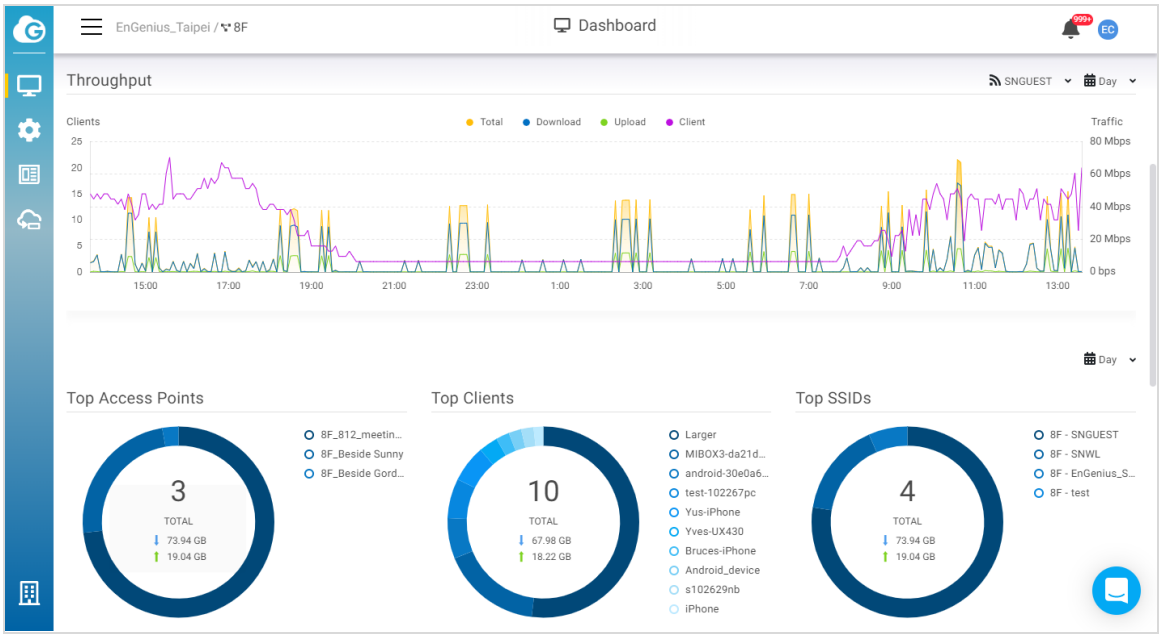
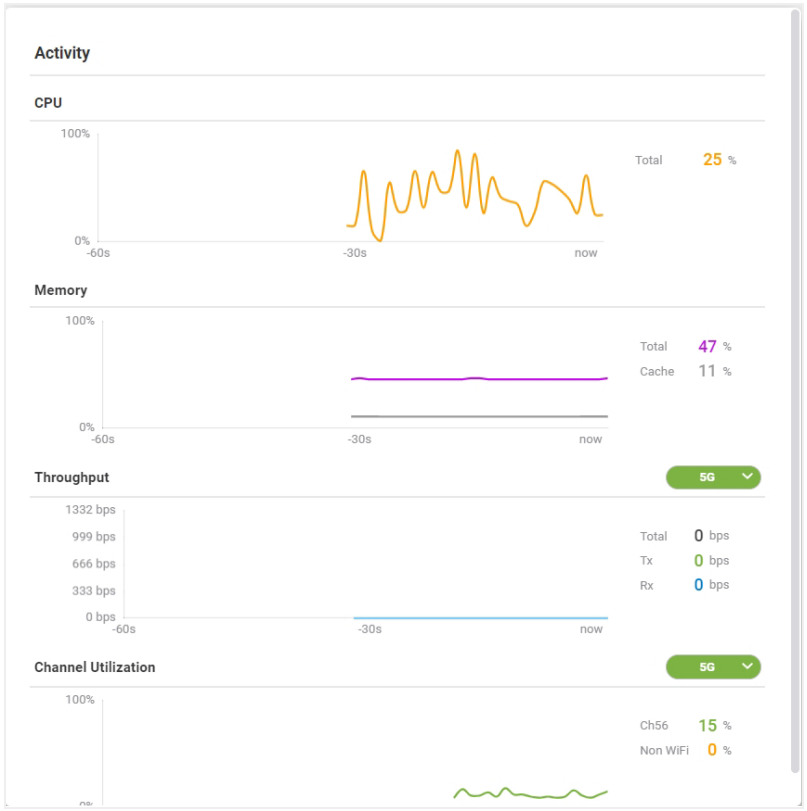
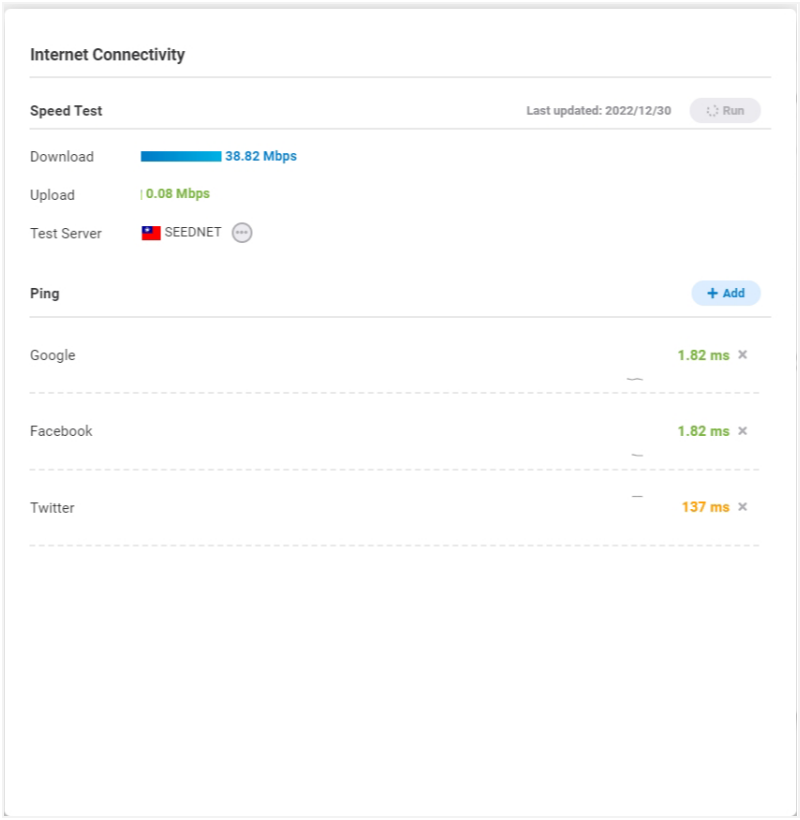


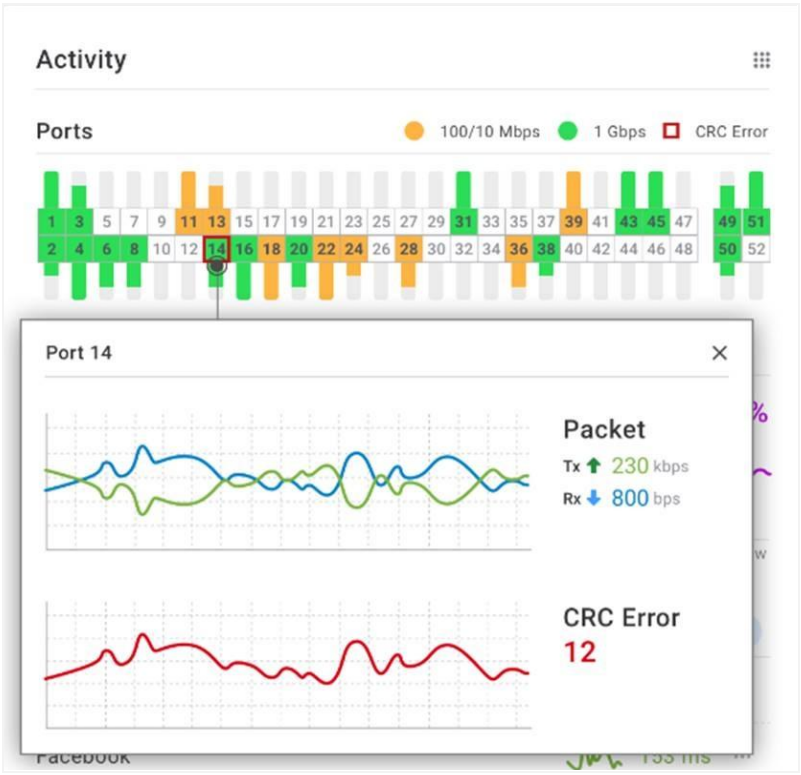
Figure 19 - *Throughput and utilization view*

Real-Time Status of Cloud Devices

Slow network performance can be caused by high CPU or memory utilization by networking devices. EnGenius Cloud will invoke a “real-time function” module, building a specific tunnel to observe the CPU/memory utilization rate in real-time, real-time channel utilization, speed test, ping, trace out, spectrum analyzer, etc.


Activity
CPU
100%
0%
-60s
-30s
now
Total 25 %
Memory
100%
0%
-60s
-30s
now
Total 47 %
Cache 11 %
Throughput
5G
1332 bps
999 bps
666 bps
333 bps
0 bps
-60s
-30s
now
Total 0 bps
Tx 0 bps
Rx 0 bps
Channel Utilization
5G
100%
Ch56 15 %
Non WiFi 0 %


Internet Connectivity
Speed Test
Last updated: 2022/12/30
Run
Download 38.82 Mbps
Upload 0.08 Mbps
Test Server SEEDNET
Ping
+ Add
Google 1.82 ms
Facebook 1.82 ms
Twitter 137 ms



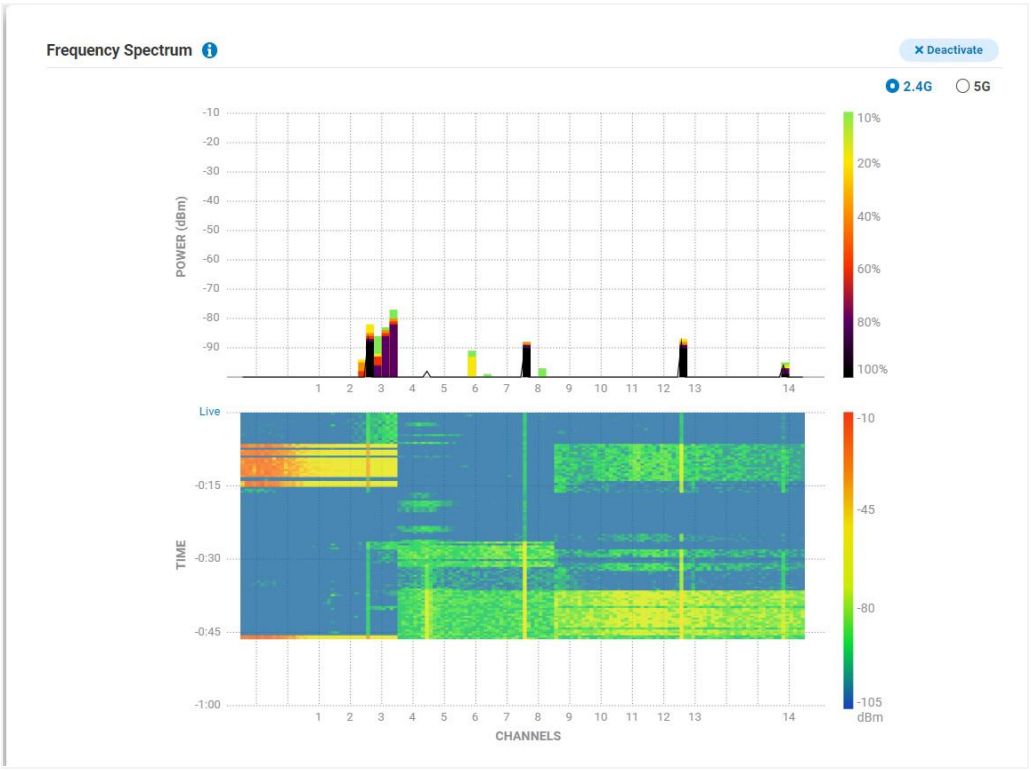


Figure 20 - *Real-Time Diagnostic Tools*

Comprehensive Event Log Report

One of the biggest headaches for IT users is to piece together threads of an issue from log files across one or more machines in a network. EnGenius Cloud automatically consolidates all log files in a single, convenient location, including system logs, event logs, and configuration changes of all managed cloud devices. Powerful filtering functions empower IT managers to simply compare and analyze data such as logs for many different devices and cloud configurations, filtering by time period, event types, networks, SSIDs, specific devices, or clients, and categorizing event states as errors, warnings, or general states.

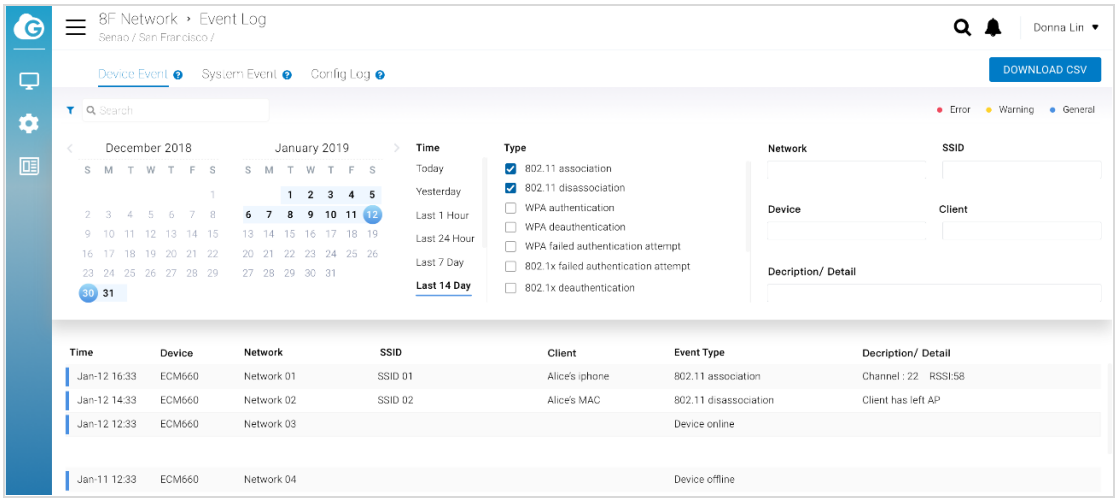


Figure 21- *Centralized event log report with powerful filtering function*

Customized Notification per Network

Continuously reviewing network statuses is not an effective use of an IT user's time. An effective notification system through email or via mobile phone saves time by pinpointing a network problem precisely when it occurs. Simultaneously the notification system has to be well-designed to prevent flooding your IT team with false notifications.

EnGenius Cloud enables users to customize their notification criteria per network base. EnGenius leverages stream processing technology to build a highly scalable, fully fault-tolerant, secure, and low-latency messaging platform to send the most important notification messages to the right people. This ensures that

critical notifications are received and minimizes an overwhelming amount of notifications to recipients when hundreds of thousands of network notification scenarios are matched and sent to multiple recipients in a network.

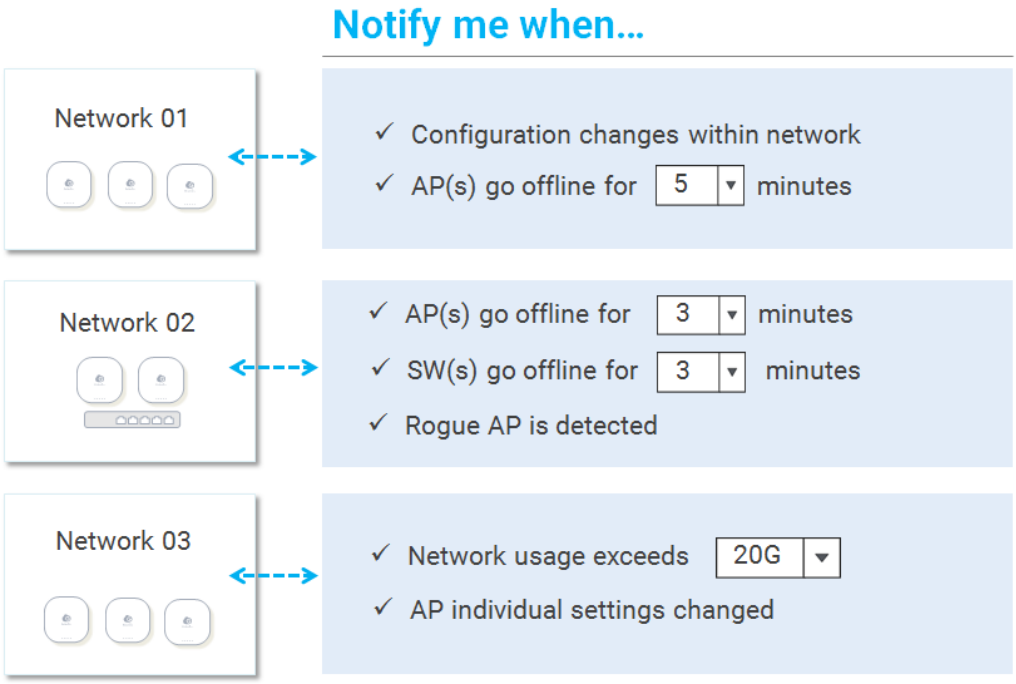
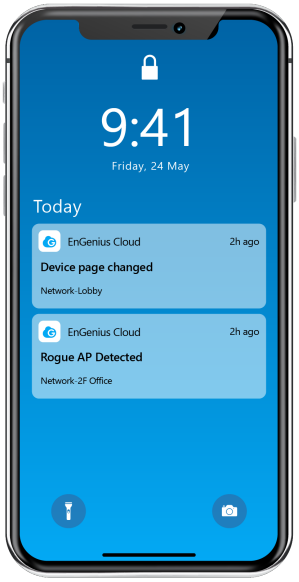


Figure 22 - *Rule-based notification customized by network*

Manage your Cloud on the Go

EnGenius Cloud provides a mobile application to help IT users stay on top of their network no matter where they go. The app provides notifications to users when there is an issue with the network and then enables them to pinpoint the source of the issue.

Users can also use the app to register cloud devices by simply scanning the QR code on the backs of devices. The configurations can automatically be pushed to a newly installed device when it is assigned to a specific network via the app.



API for MSP and Eco-Partners

EnGenius Cloud provides a complete set of APIs for MSPs and Eco-Partners to extend and customize the capabilities of EnGenius Cloud. We offer the flexibility to change the theme, frontend design, add-on modules, traffic redirection, and even add new IoT devices in one convenient place.