



White Paper

Visualize Your Networks with AI-Driven EnGenius Cloud

Rev. 2.2

This article demonstrates how EnGenius Cloud achieves reliable and scalable cloud infrastructure and the unique features it offers 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. From Recent market reports, Cloud-based Networking deployment will still have over 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, FitController to locally or remotely manage EnGenius switches and Access Points. Users simply need to plug in the FitController to one of the switch ports in the network ,then it can manage local Switches and AP's as an On-premises deployment, so that all management plane will stay in local FitController. In recent years, due to the demand of Cloud-based register-then-manage without any installation, 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 EnGenius Cloud solution. Thus IT users simply need to focus on how they want to manage their networks, without worrying about server capacity, performance and scalability.

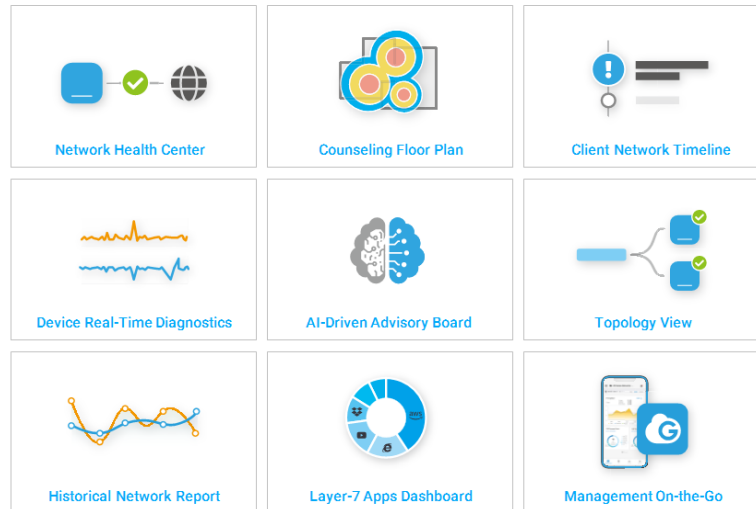


On Premises	Cloud
EnGenius FitController Solution	EnGenius Cloud

Figure 1 - EnGenius On-Premise and Cloud Solution

AI-Driven Network Visualization

In accordance with the EnGenius corporate philosophy of ease-of-use and providing customers “meaningful” information instead of hard cold technical terms, the company seeks to provide customer meaningful advice based on AI-driven analytics and reduce customer pain points with tools for easier planning, deploying, and managing. EnGenius Cloud brings the networking management to the next level, offering users the ability to visualize how good is the network and, further, advice on what could go wrong and where to fix it. EnGenius Cloud has also built a fully scalable Serverless platform to reduce dramatically the downtime, and the same time, secure the data.



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. In response, EnGenius built the first-generation cloud to deploy a customized instance of ezMaster manager, the 1st generation of 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.

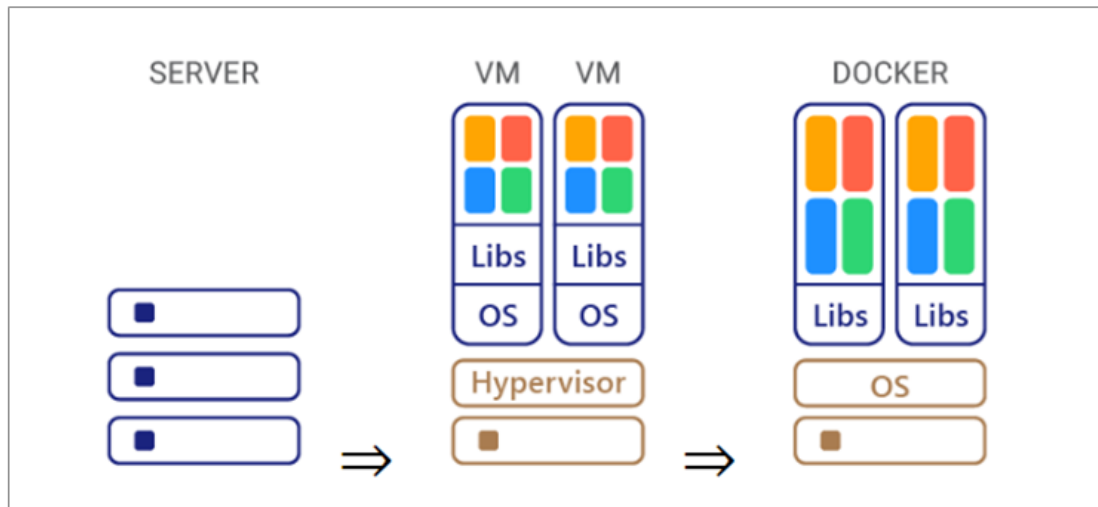


Figure 2 - Server vs. Virtual Machine vs. Docker

Note:

Server-Based Cloud - physical machines placed in cloud data centers with specific CPU, memory, etc. Similar to traditional IaaS services.

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

In our daily experience, cloud services should be able to handle needs both large and small, 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. 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 we find there are lots of cloud deployments like what we did for the 1st generation by putting their Controller image into a Cloud VM to make their Cloud solution. However, as stated above that it will be hard to move the devices across the different organizations, hard to move the license, hard to have several tiers of administration across regions, and have many limitations to manage multi-tenants, especially for MSP deployment.

Next-Generation Serverless FaaS Cloud

Serverless infrastructures abstract the server components and adjust for scale based on event-driven function requirements. Whenever there is a new function request, appropriate resources will be allocated based on the function characteristics. Serverless design not only increases the resource utilization rate, but also improves performance for each function. Serverless design is therefore referred to as FaaS (Function-as-a-Service) design.

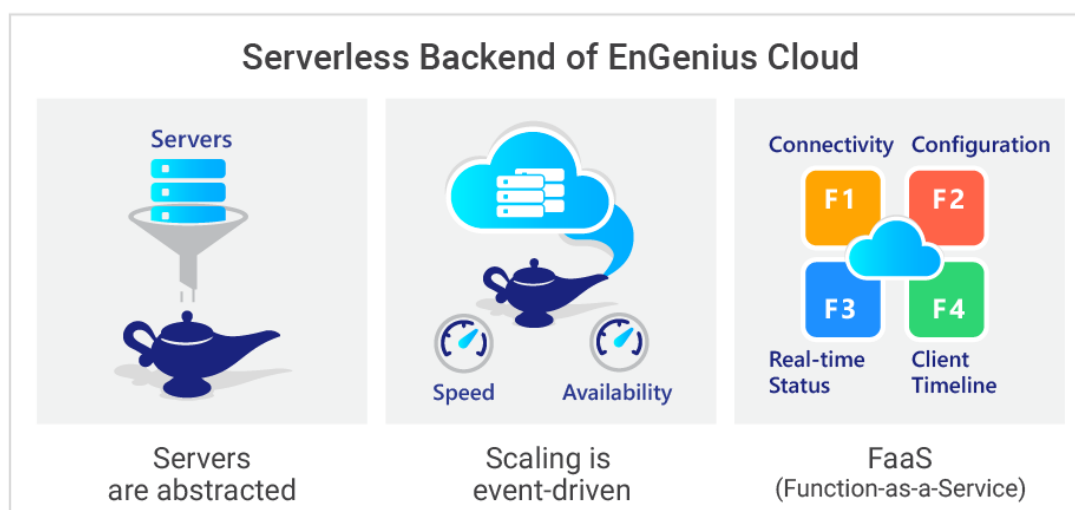
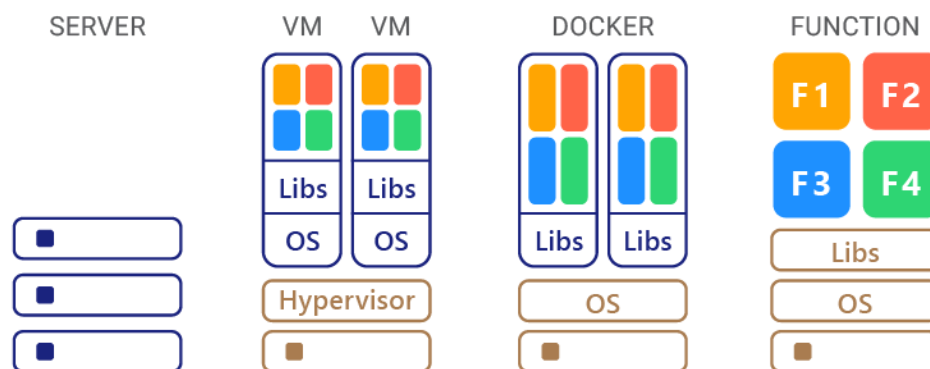


Figure 3- *Serverless Cloud*

There are many different functions in network management, 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 size of the database. 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 needed. It is also constrained by the size of the database, and the limitation of applications. When moving to a different scale environment is required, it will take from 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, as well as quick reduction of resources when demand for resources is lower.

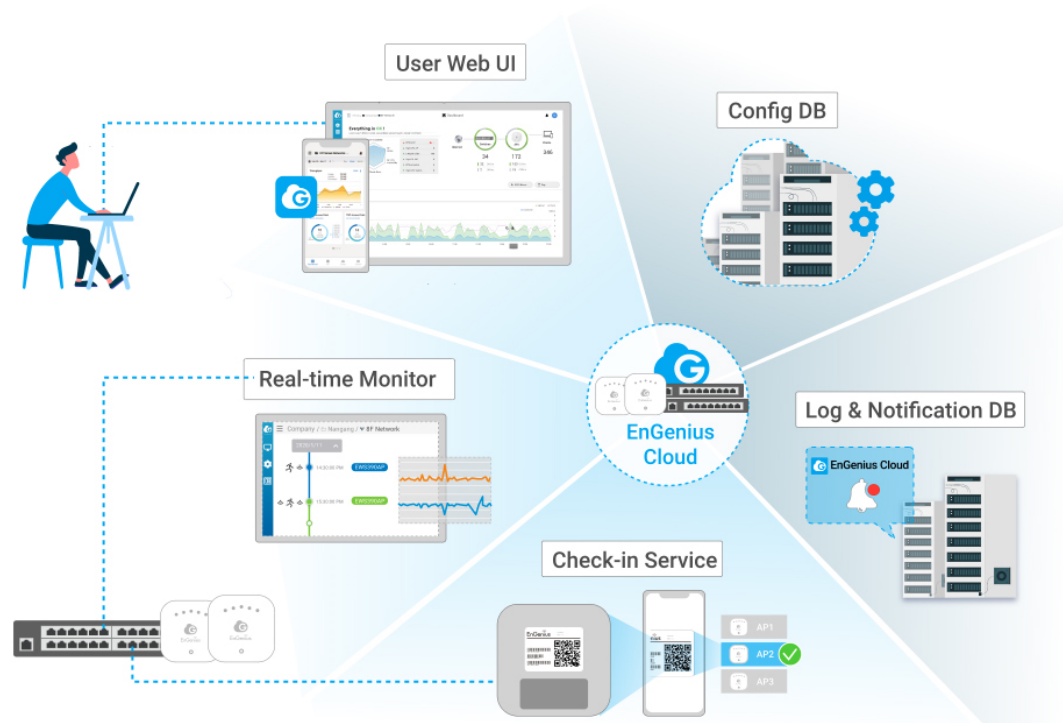


	Server	VM	Docker	FaaS
Scale Boundary	On Premises Machine	Machine	Machine & Application Libs	Function (Micro-Service)
Run Time	Days–Months	Hours–Months	Minutes–Days	Micro-Sec-Sec onds
Cost	New Server	Per VM	Per VM	Per Request
Solution	On-Prem FitController	On-Prem FitController on AWS	1st Generation Cloud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

Figure 4- *Comparison between different cloud architecture approaches*

EnGenius separates the controller into 6 major functions and each function has its own cloud service design and communication protocols based on the function needs, and each function components can base on it's loading to scale by itself without impacting other function, such that the FaaS (Function-as-a-service) design makes EnGenius Cloud highly resilient and highly scalable. The 6 function components include:

- User Web UI
 - It handles all user web interface
- Check-in Service
 - It handles all device connectivity and communication
- Configuration DB
 - It stores all configuration of the Networks that users set through User Web UI, then deploy 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 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 EnGenius Cloud plays a key role to allow users to see that real-time information like all devices are always connected.
- EnGenius Cloud Engine
 - It plays as an orchestra conductor to glue all services tightly together



Passing Cost-Savings on to Customers

The other key benefit of Serverless FaaS architecture is cost savings. Research conducted by Libhiv 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 SMB customers.

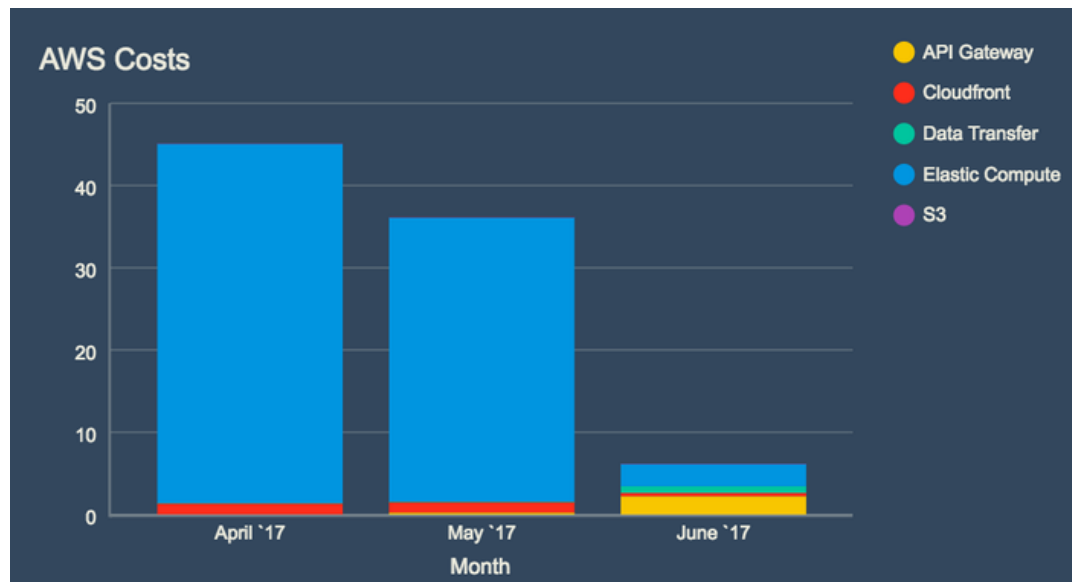


Figure 5- Cost saving in June after leveraging serverless technology (API gateway in this case) Source: Libhive

Secure Cloud-Connected Device

Cloud user's data will not go through EnGenius Cloud, so the user has full ownership of his secure data. EnGenius Cloud only collects Cloud devices' management information for user easy management purposes. As to the 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 built-in a security key from the manufacturing factory for the 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 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.

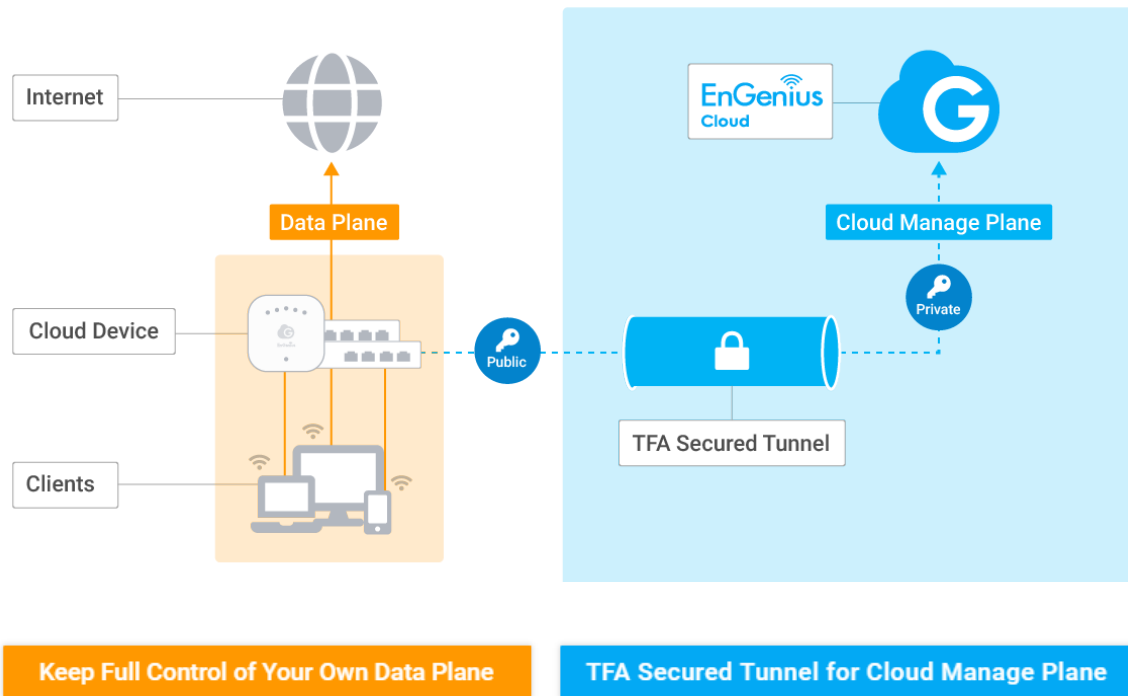
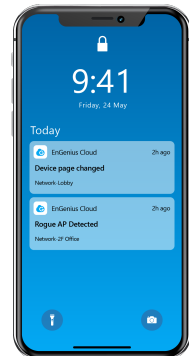


Figure 6 - Secure tunnel for management plane

Plug and Play - Easy to Manage Remote Office

For EnGenius Cloud implementations, the network administrator at Headquarters (HQ) 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.



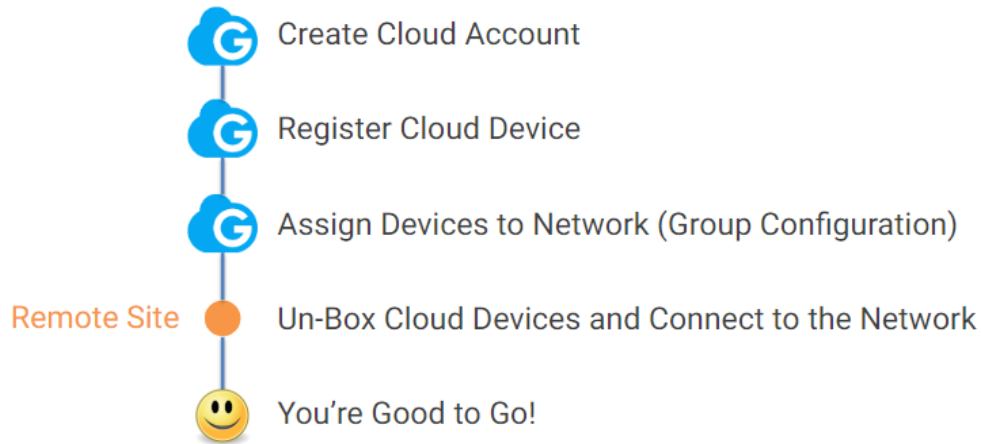


Figure 7 - Simple steps for Plug-and-Play in EnGenius Cloud Solution

Reconfigurations and/or professional visits are not required or needed with local failed devices. Any member of a remote branch can RMA a local failed device by simply informing HQ 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 branching network hierarchy, including a combination of central IT management with total 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 both the US and EU regions, and more branch offices under US and EU, so the IT users in the US region of tenant B can only manage for the US region.

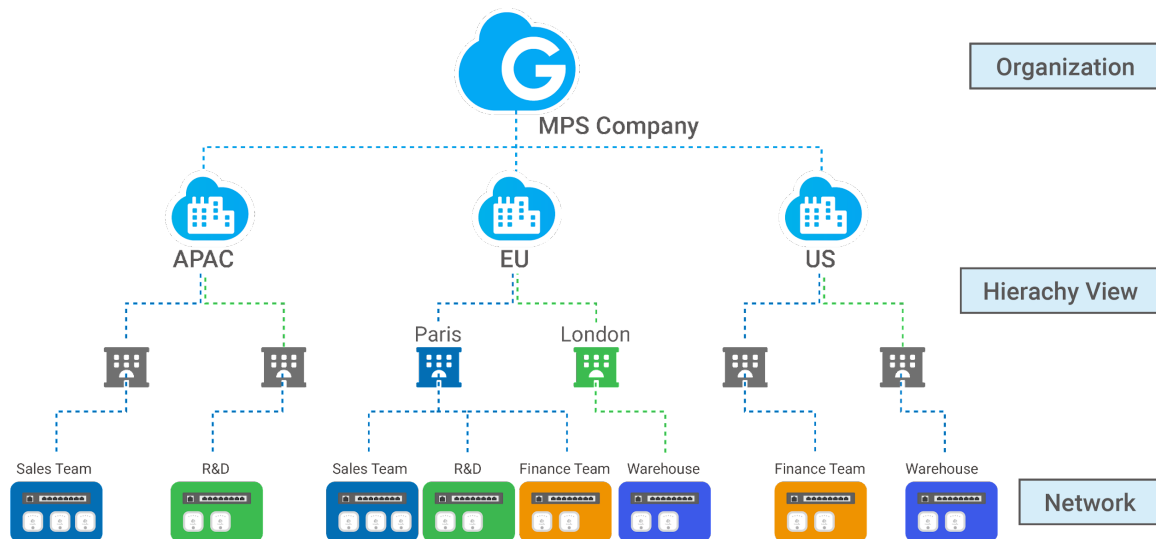


Figure 8 - Cloud design structure of a multi-tenant MSP company

Multi-User Privilege

There are 2 basic user roles: *administrators* with full access privileges and *viewers* with read-only privileges. There are 2 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 full inventory control.
 - Two administrators are highly recommended to prevent email lockouts

- Administrator email is recommended to use the same domain as the company domain, so administrator activation and notification can only be received through the company email server
- Network Level: has the permission to access a specific network and devices under the network.

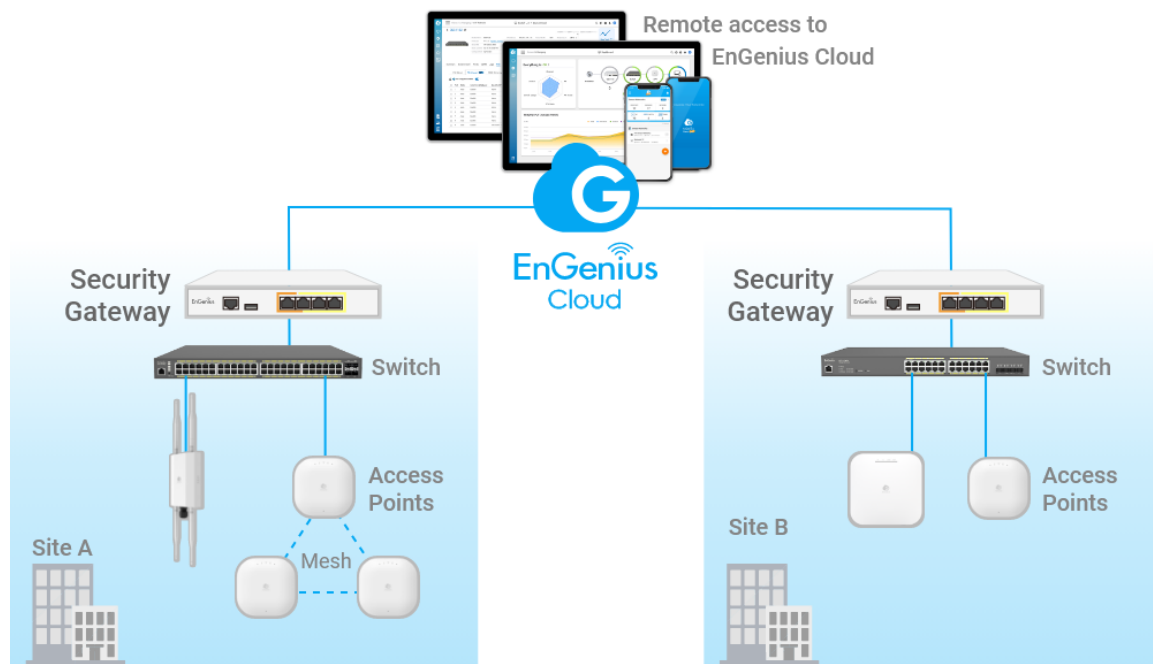
There is no need for separate Hierarchical View privileges since HV is a group of other HV's and networks, so all permissions are based on the permission of networks the user has privileges to access. For example, a user with permission to access finance and R&D can see both the US HV and New York HV, 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 includes Security Gateway, Switches and Access points, so the users can manage the whole network from single pane of glass to have a holistic view and find the issues in a short time.



AI-Driven Advisory Board

One of the most challenging jobs for an IT user is to diagnose a technical problem from the vague and non-technical descriptions of their customers. For example, the problem described as “cannot access the Internet” might have many potential sources and require different approaches to further investigate further and respond correctly. EnGenius assist IT users to resolve problems with educational visual tools to resolve potential issues as illustrated below.

From below figure 9, when the channel utilization of an AP is high, it may be because data throughput is high, yet it might be because someone else is using the channel as well, which will cause the beacon stuck of the AP or co-channel interfering with neighbor AP, or many other reasons.

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. If users feel the behavior is suspicious they can decide to discover more. Then the Advisory will look into other parameters. If there was a beacon stuck issue in a log it would advise checking with your floor plan. 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.

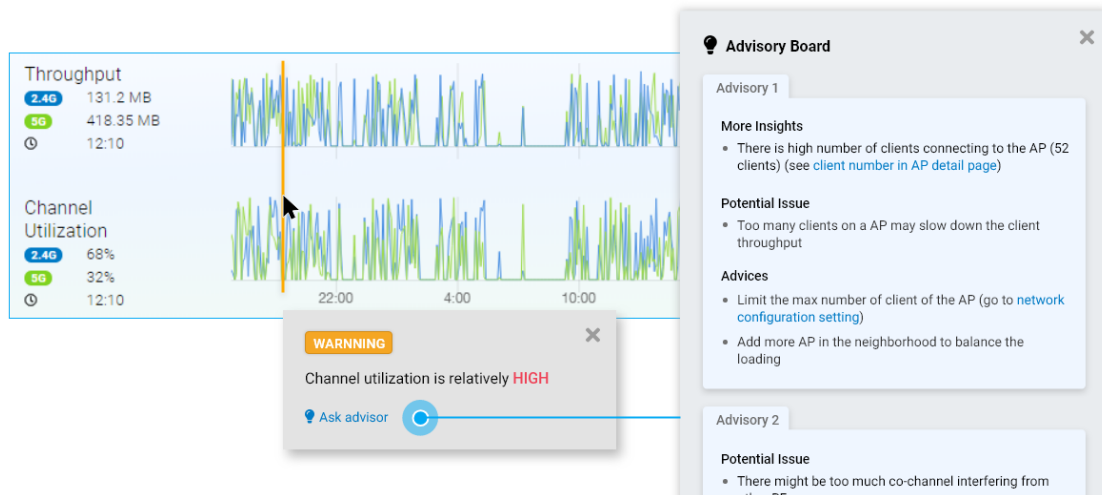


Figure 9- AI-Driven Advisor to lead the way to pinpoint real issues

Client Timeline

Instead of only providing users the client lists attached to the APs, EnGenius Cloud records each client's journey in the network with timestamps. IT users can pull up the entire client history using client MAC addresses or device names. This includes the AP that is connected to, the authentication status, and the time required to roam to another AP, so the IT manager does not need to wait for his customer to describe the symptoms, and knows what could the problem be.

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 send the packets back to the access point accurately.

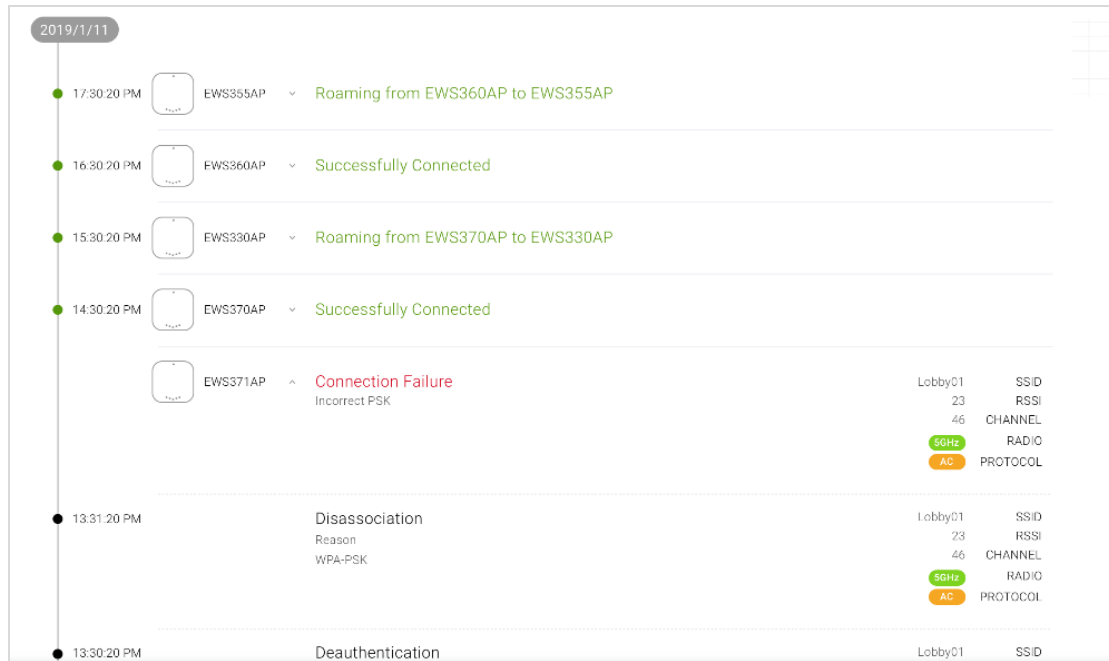


Figure 10- Client Timeline

AirGuard WIPS to Protect the Environment from Rogue attack

AirGuard is EnGenius WIPS/WIDS technology to detect all malicious attacks like Rogue AP, Evil Twin, Man-in-the-middle, and RF jamming, then base on users policy to automatically prevent the clients to connect to those rogue AP's.



Auto VPN for Continuous VPN connection

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

EnGenius Cloud-managed security gateway allows users to simply click one button and built the Site-to-Site VPN mesh connections without any troublesome configuration of WAN IP, ports, authorization, and encryption protocol settings.

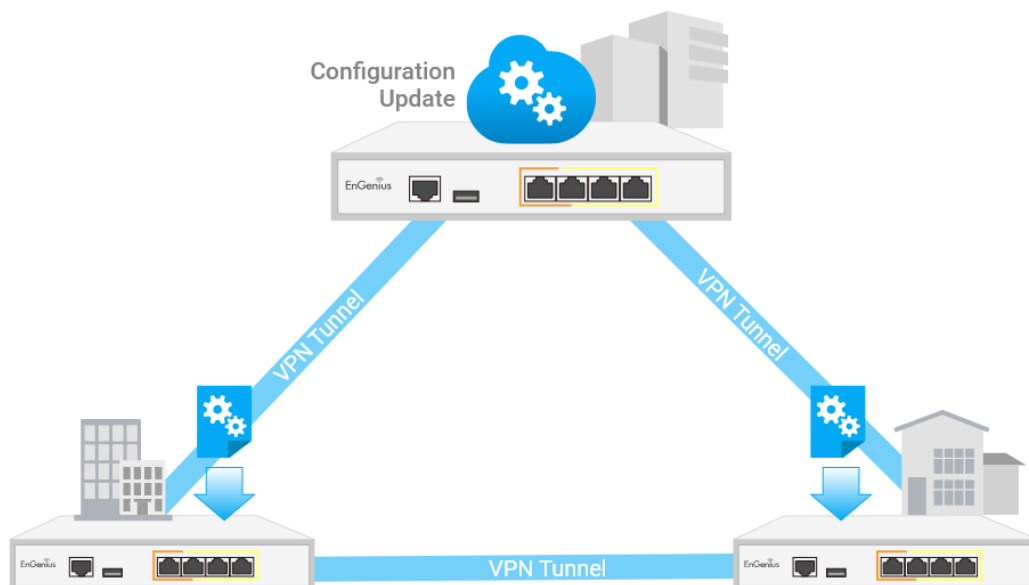
To be able to simplify the whole setup process, EnGenius Cloud leverages the “Cloud-managed device” nature in that all devices will initiate and talk to EnGenius Cloud to update their current WAN IP and ports, so when the VPN connection is required, EnGenius Cloud has a VPN registration center to keep all information required in the Organization to share remote peers information to the peers and make the VPN connectivity.

Self-Healing VPN Topology

ISP might change your gateway WAN IP from time to time. When the WAN IP is changed, EnGenius Cloud is notified by EnGenius Gateway so to notify all VPN-connected peers to change the WAN IP accordingly

Auto NAT Traversal

When the gateway resides behind a NAT device, it complicates the VPN setup that the user needs to set up IP ports to map correctly so be able to build the connection. EnGenius Cloud uses hole-punching technology to make the devices talk to EnGenius Cloud and keep updating the WAN IP/Port to build the VPN connection.



Integrated ezWiFi Planner Completes the Cycle from Design to Result

EnGenius customers have been enjoying the subscription-free benefits of the award-winning ezWiFi Planner tool to plan their next network deployment by simulating the environment with obstacles and advice on the placement of APs.

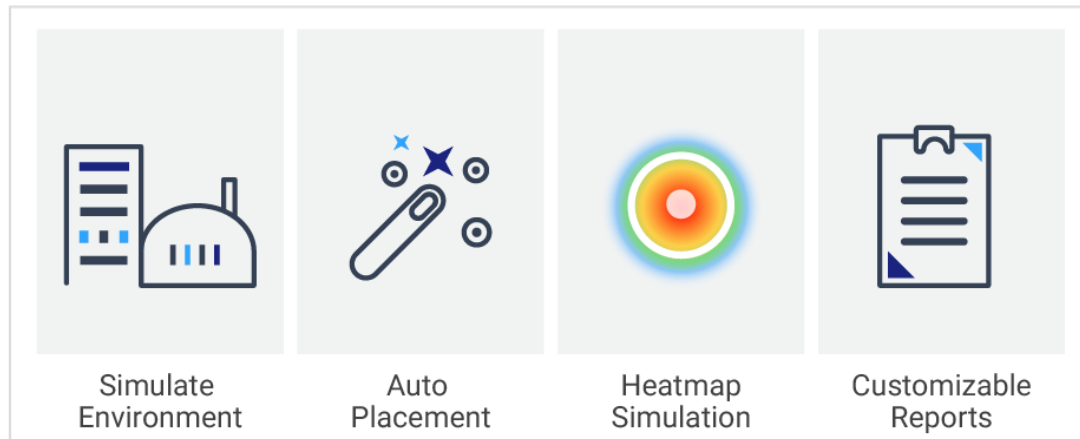


Figure 11 - Award-winning ezWiFi Planner simulates AP locations to cover required Wi-Fi areas

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. (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 and 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 is capable of drawing up more accurate real-world conditions in making its deployment assessments. Obstacles and congestion areas now play a greater role in predicting a coverage area as accurately as possible. This is in contrast to other heatmap software, which makes a naïve assessment of conditions when displaying its AP heatmap.



Figure 12 - Embedded heatmap tool in EnGenius Cloud

Some would 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, then the survey results are less useful after transmission power and channel changes because the site survey can only measure Wi-Fi as a snapshot in time. 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.

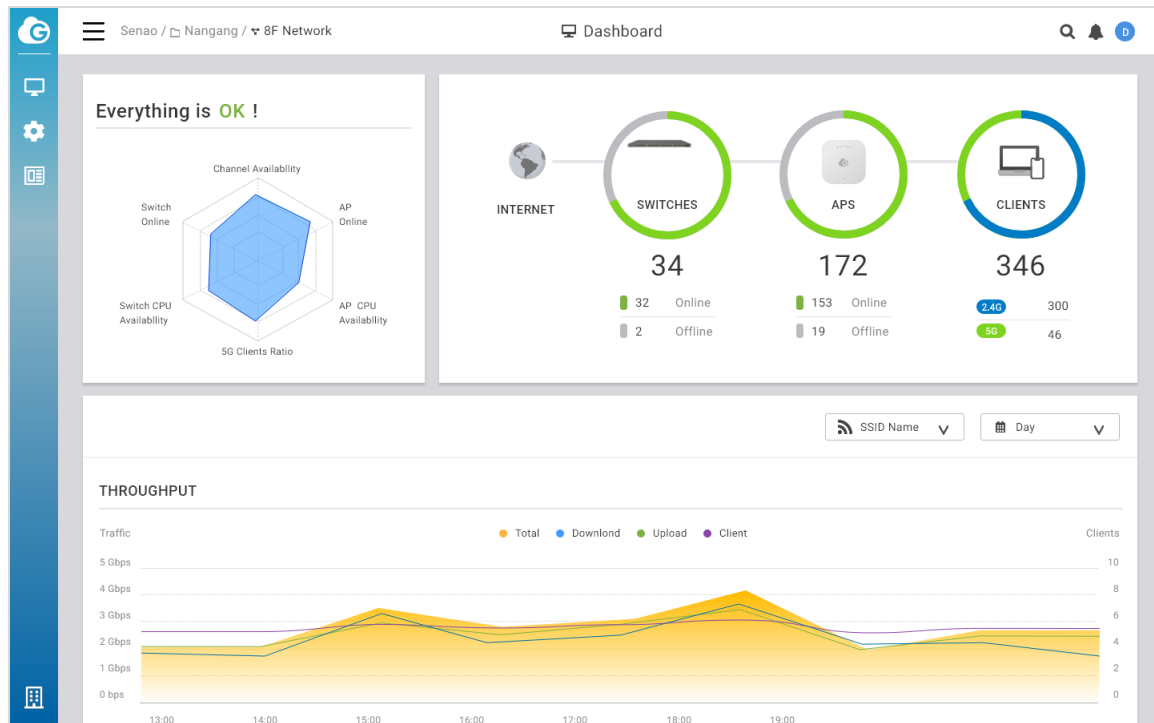


Figure 13 - Holistic health check view of networks

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.

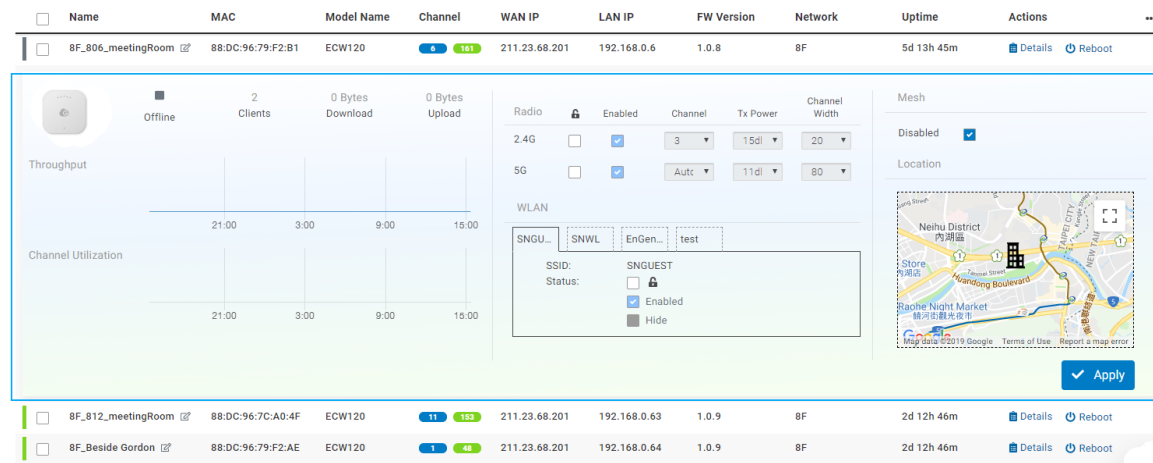


Figure 14- AP device list view with quick dashboard

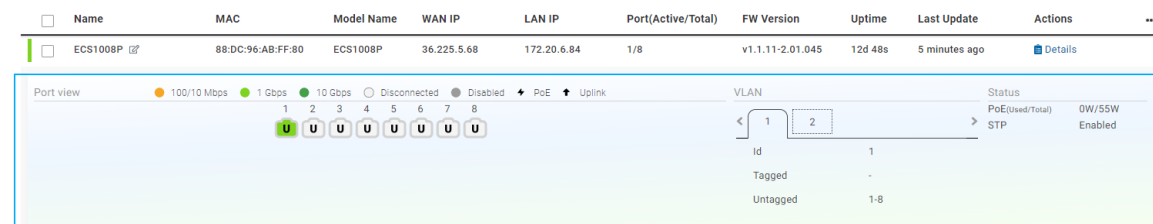


Figure 15- Switch device list view with quick dashboard

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 a Layer 7 DPI engine embedded 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.

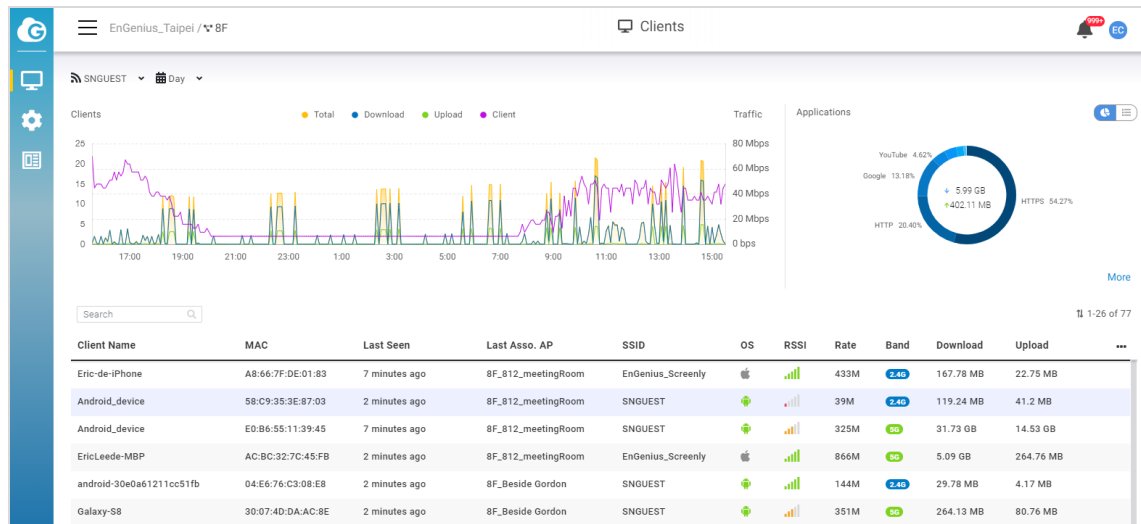


Figure 16 - Client list view with Layer 7 application aware traffic dashboard

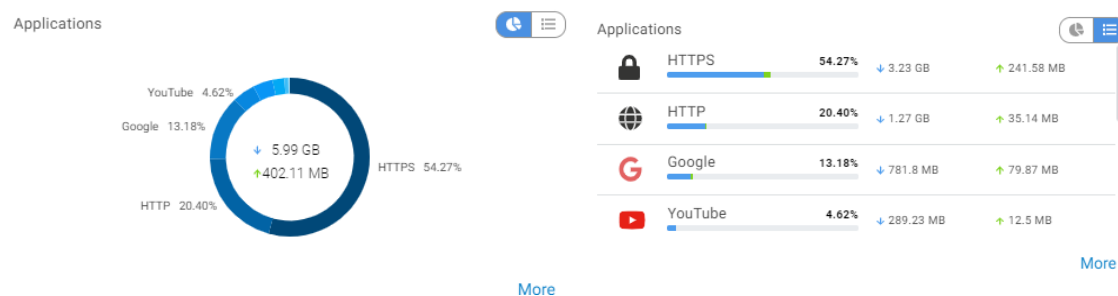


Figure 17 - Switch device list view with quick dashboard

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 switches and APs in a single overview. IT users can, for example, locate a specific switch and switch port that is 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 the LAN link issues are the sources of the problem.

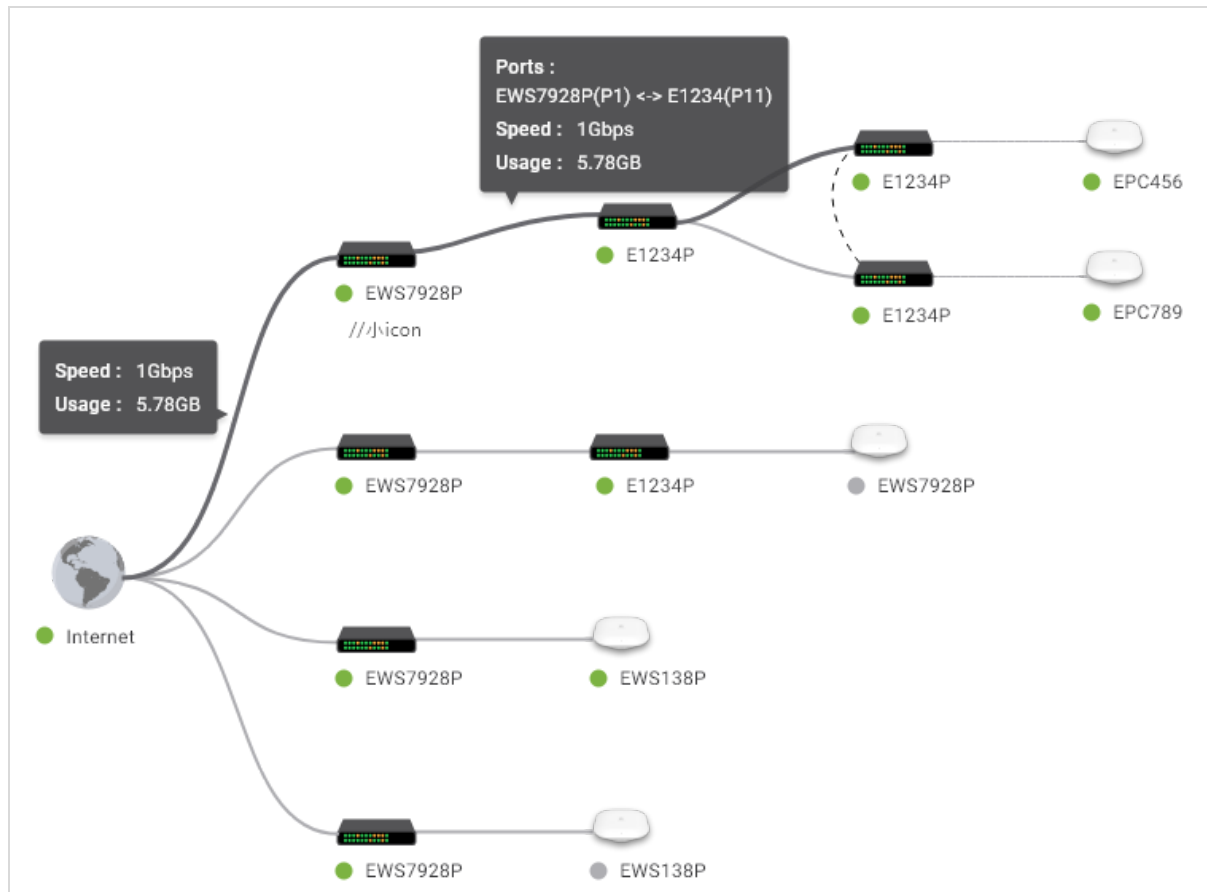


Figure 18 - Topology View

Troubleshooting with Insight Visualization

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

Historical Statistics Dashboard

When there is a specific AP 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:

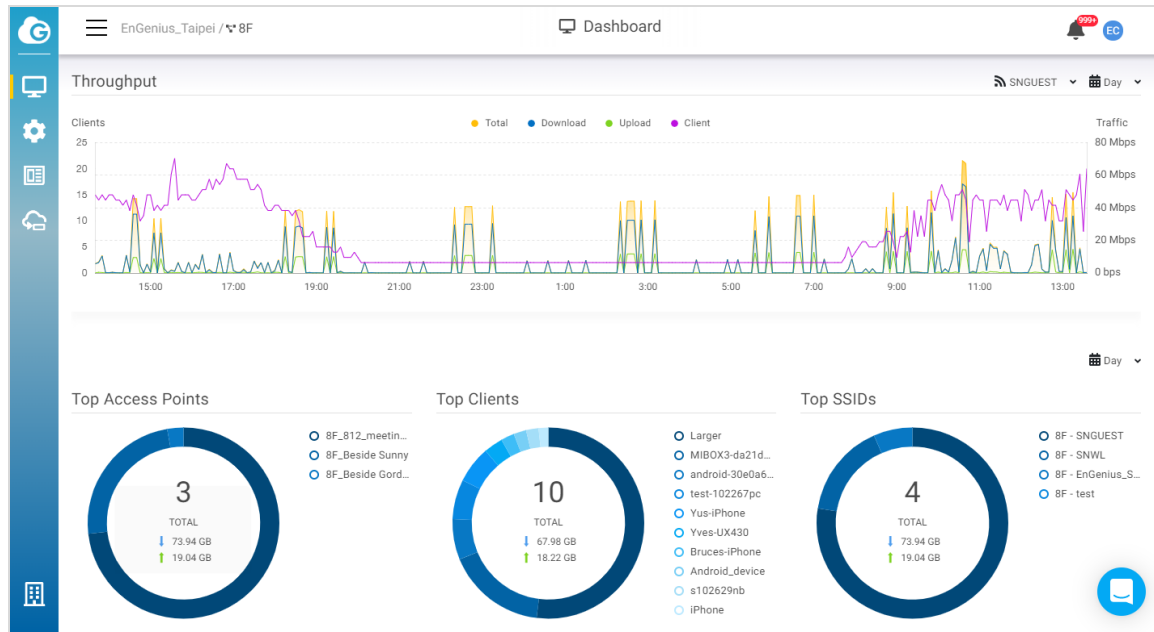
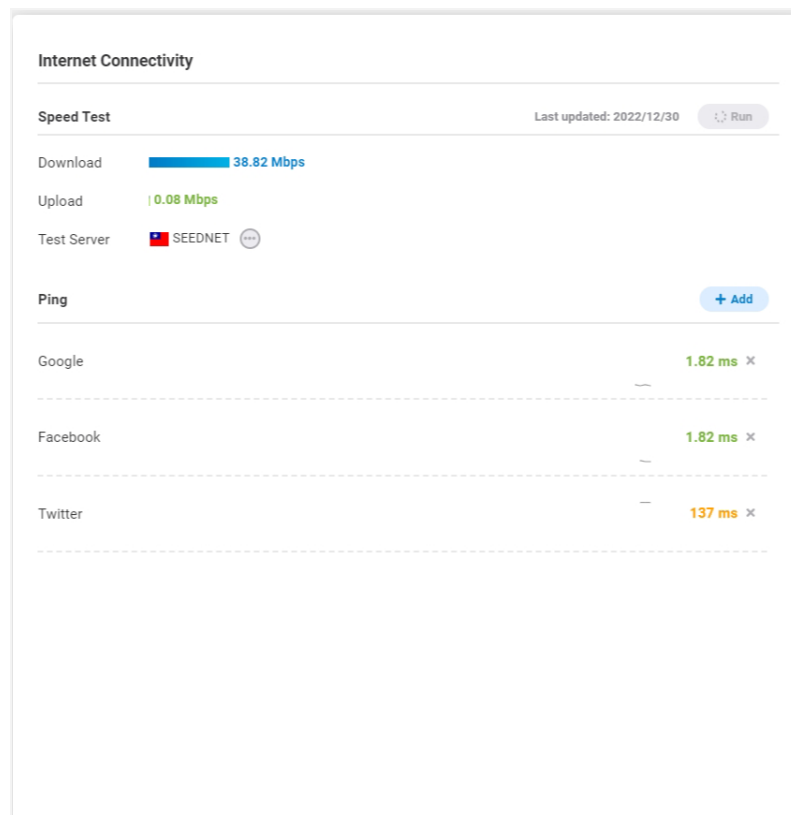
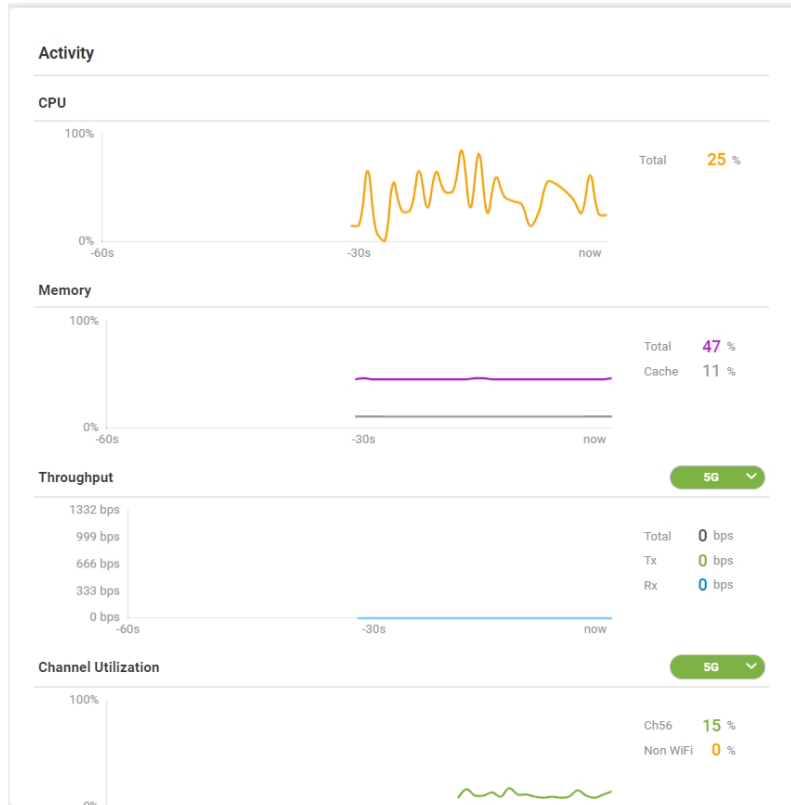


Figure 19 - Throughput and utilization view

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, and real-time channel utilization, speed test, ping, traceout, and spectrum analyzer...etc.



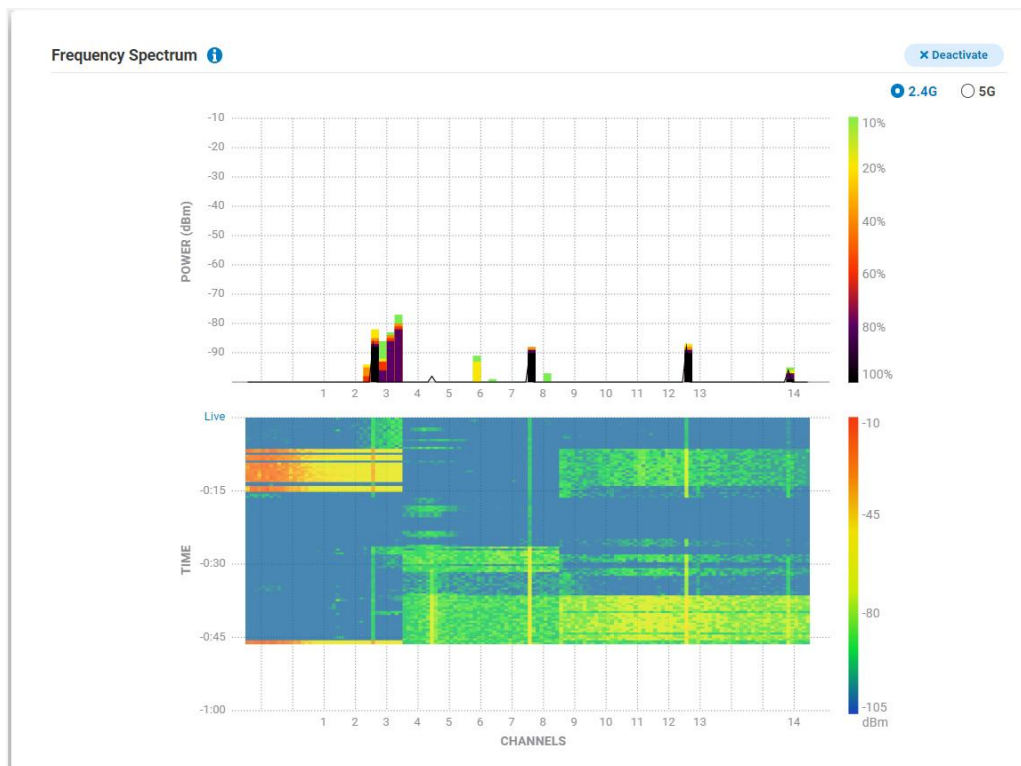
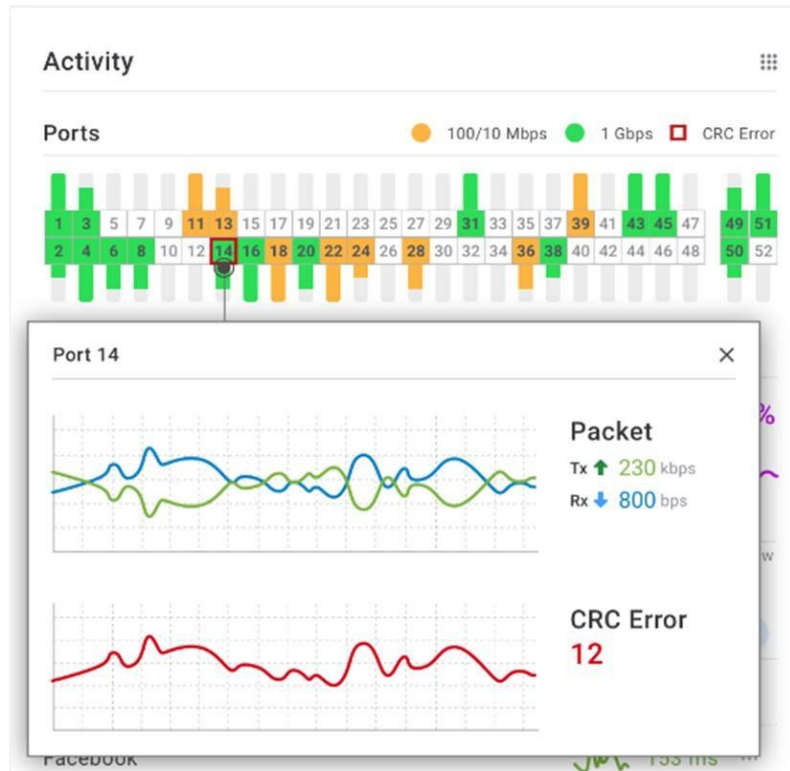


Figure 20 - Real-Time Diagnostic Tools

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 log, event log, 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, categorizing event states as errors, warnings, or general states.

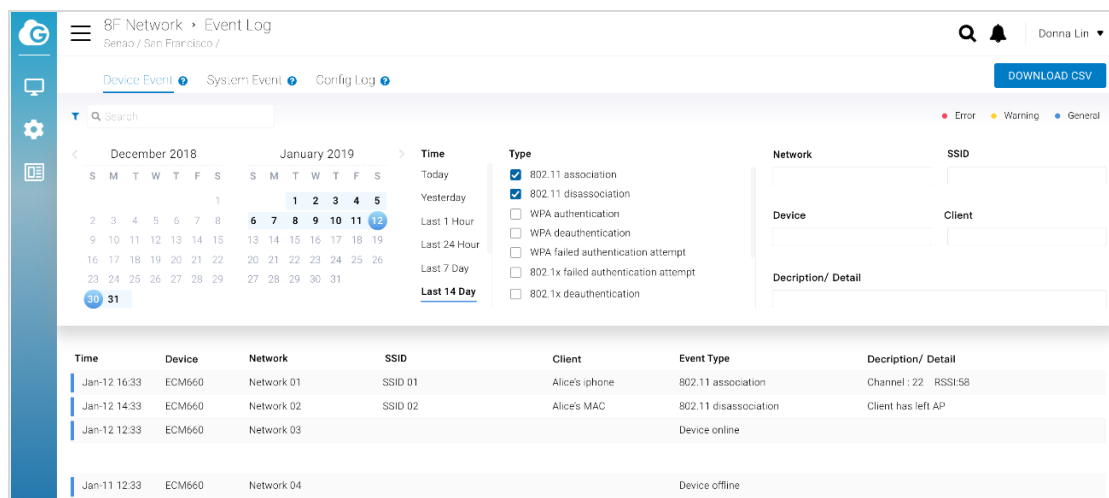


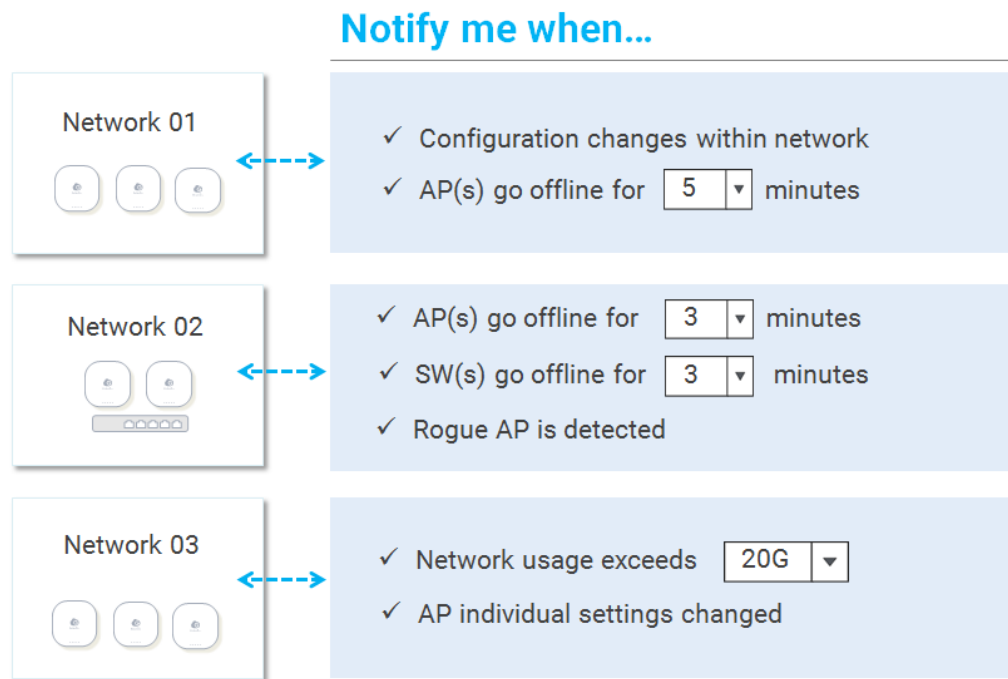
Figure 21- Centralized event log report with powerful filtering function

Customized Notification per Network

Reviewing network statuses continuously 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 at precisely the moment that it occurs. Simultaneously the notification system has to be well-designed to not flood 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, full 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 there are hundreds of thousands of network notification scenarios to be matched and sent to multiple recipients in a network.



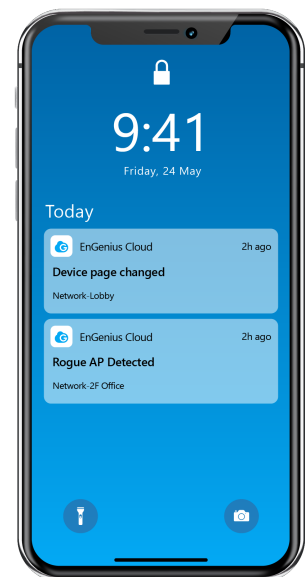
11

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, all in one convenient place.