NetExperience White Paper

The NetExperience Cloud Management and Controller Platform: A disaggregated approach to WLAN management and control

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Executive Summary

The traditional approach to deploying and managing both public and private service provider (SP) Wi-Fi networks involves the use of vertically integrated wireless local area network (WLAN) equipment vendors, which offer proprietary access points (APs) as well as controller and operations, administration, and maintenance (OAM) products.

Currently, NetExperience is revolutionizing this previously established WLAN vendor ecosystem by enabling SPs to deploy a single orchestrated Cloud WLAN solution. This solution is compatible with a wide range of Open Wi-Fi certified APs, which are available from numerous hardware manufacturers.

The NetExperience Cloud Management and Controller platform enables a single management and controller platform to be deployed in all market verticals, from high-end enterprises and public hotspots, to residential areas and multiple dwelling units (MDUs). This allows for the fulfillment of specific, unique Wi-Fi network requirements present in a diverse range of niches.

Industry Context

The current enterprise architecture (EA) for WLAN services is central to the vendors of AP hardware. Proprietary hardware variants, as introduced by WLAN vendors, are aimed at specific market verticals and follow industry evolutions as outlined by the 802.11 standards and its associated silicon implementation. WLAN vendors typically partner with Asian-based AP manufacturers to integrate the latest silicon variants into the newest AP models. This starts with the silicon vendor's reference designs; however, the AP software implementation itself remains the AP vendor's individual responsibility. Thus, the software architecture relies on the silicon vendor's proprietary software reference designs, which are augmented by AP vendor-specific middleware and entail enhancements aimed at differentiating their offerings to the market.

The control plane of the WLAN relies on a centralized element, the WLAN Controller, that is hosted either on the premises as a network appliance or as part of the WLAN vendor Cloud offering.

The "vendor-locked" architecture approach results in the implementation of a fully vendor-specific WLAN that is comprised of hardware models, AP and controller software, AP and controller signaling protocols, and OAM solutions. By design, interoperability between WLAN equipment vendors is not possible.

The proprietary nature of current architectures may force Wi-Fi SPs to adopt solutions from several WLAN vendors simultaneously, each of which is optimized for specific, differing market verticals. This may lead to operational expenditure (OPEX) becoming a major expense for Wi-Fi SPs due to having to train personnel on the vastly different available WLAN vendor solutions.

Thus, the need for an alternative approach to WLAN solution architecture based on open, disaggregated hardware-software components is driven by this industry's momentum towards open-source, community-lead innovation and the necessary requirements for cost-effective WLAN solutions for areas where traditional
Wi-Fi broadband solutions are far too expensive.

Driving The Ecosystem Revolution With Open Wi-Fi

In 2019, NetExperience partnered with the Telecom Infra Project (TIP) to embark on the task of developing the world's first end-to-end disaggregated enterprise grade WLAN architecture.

The resulting Open Wi-Fi architecture is now comprised of the following elements:

- AP Software (APNOS):
  - o APNOS is a complete open-source AP real-time software stack that leverages open-source Wi-Fi chipsets, Linux drivers like the QCA Ath11k driver, and OpenWrt. It also involves a control and communication software agent that is responsible for AP-to-Cloud signaling, telemetry, and provisioning communication protocols.
- Cloud Platform Software (CloudSDK):
  - o CloudSDK is a set of open-source JAVA services that provide the necessary software components for third party WLAN controller solution providers to run their applications on either a public or a private Cloud. The software components involved include Kubernetes infrastructure, an AP-Cloud communication gateway, database services, an AP firmware loading service, a provisioning service, streaming of near real-time network metrics and events, user interface (UI) services, and REST API services for Cloud-to-Cloud communication.
- Hardware Specifications:
  - o These complete AP hardware specifications are necessary for AP manufacturers to be able to build both indoor and outdoor AP models that are TIP-compliant.
- QA/DevOps Infrastructure:
  - o A TIP-lead set of infrastructure for DevOps and automated QA allows for the ongoing validation of open-source software code that is continuously contributed by members of the TIP community.

NetExperience partnered with industry-leading AP manufacturers to introduce the world's first commercial offering for a full end-to-end enterprise grade WLAN solution based on Open Wi-Fi. This entailed leveraging the TIP open-source components that have been augmented by an innovative Cloud Application Software Layer (CMAP). The first GA release of this offering was available in May 2021. This end-to-end solution is currently under deployment, with several Wi-Fi SPs already active around the world.

NetExperience: Enabling Large-Scale WLAN Open Wi-Fi Deployments With SPs

NetExperience At-A-Glance

NetExperience was founded in 2019 by a strong engineering team with decades of experience building WLAN solutions for SPs. From the beginning, this company was created with the dual mandate of building an industry-revolutionizing Open Wi-Fi ecosystem in partnership with TIP while also developing a full end-to-end commercial solution for SPs. In addition to the software and QA engineering teams, NetExperience has built up technical support and network architecture teams that are available to offer their consultation services for their customers.

The NetExperience WLAN solution is offered as a full software stack that either runs on the NetExperience Hosted Cloud environment as a SaaS model or as fully licensed on the SP private Cloud environment.

The NetExperience Management and Controller software platform was built using a proprietary WLAN CMAP that runs atop the open-source TIP Cloud platform CloudSDK.

CMAP: A SP-Centric Application Layer

The NetExperience Cloud software was architected from the perspective of a Wi-Fi SP's set of requirements. The key features of this SP-centric application layer include future proof supporting an always-evolving set of hardware models, multi-tenant operations, an intuitive provisioning flow, network automation, and advanced diagnostic features.

Hardware Agnostic Architecture

CMAP communicates to WLAN equipment using hardware agnostic architecture that is comprised of a set of internal data models and associated APIs. This approach allows for future proof of operation of Cloud applications regardless of any changes to or evolutions in the AP-to-Cloud communication protocols. Therefore, the NetExperience Management and Controller software platform is compatible with both releases of the TIP AP Cloud communication agents.
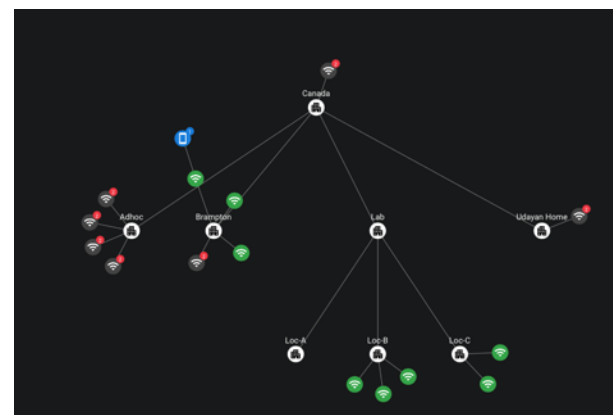
Service provider view of a network.

In the first release of TIP, TIP R1, the OpenSync© agent was embedded in the TIP APNOS and used both MQTT and OVSDB for signalling Cloud communication.

In the second release, TIP R2, the TIP architecture added support for the uCentral agent, which provides an OpenWrt native communication protocol to the Cloud using JSON encoding over a secured WebSocket connection.

The object data model managed in the AP is very different between TIP R1 and R2. Thus, the unique, abstracted NetExperience application layer allows for the seamless operation between the two TIP signaling protocols. Furthermore, the capability of AP upgrades from the CMAP application is supported, which allows for the easy migration of existing TIP R1 AP networks to the latest TIP R2 software loads.

Multi-Tenant Operation

The NetExperience Cloud Management and Controller platform provides all the necessary tools and features for SPs to manage their own customers. The SP is given access to their own unique Web Portal on the multi-tenant Cloud platform (SP Portal). SPs can define multiple user accounts with their associated privileges, such as Admin, Monitor, and R/O, to allow for their own technical personnel to access the SP portal.

The SP Portal user can create unique Customer Accounts for each of their B2B customers. Using the SP Portal, SP technical personnel can monitor all their customers' accounts at-a-glance and perform customer-specific management services as required. The Customer IT Portal (CIT Portal) allows the SP end customers to perform basic network provisioning, surveillance, and troubleshooting for their own networks.
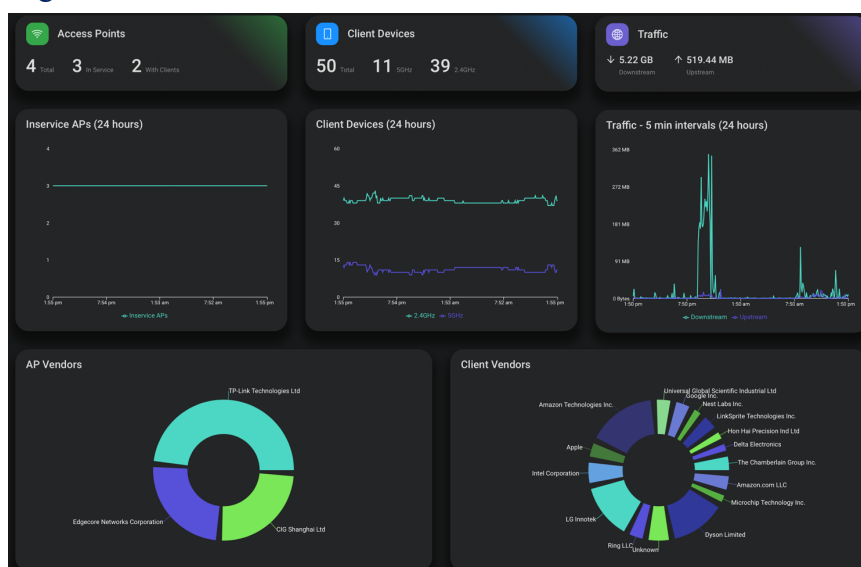
Customer portal/board.

NetExperience also provides a simple intuitive mobile app that allows for the easier onboarding of new APs. This is done by scanning the unique AP QR code along with enabling the capability of the local network's management, such as network KPI retrieval, and provisioning actions.

A Workflow-Based Provisioning Approach

To simplify the provisioning of large-scale WLAN networks, a set of intuitive provisioning profiles is available from the Portal UI. The profile architecture is based on an intuitive flow of

provisioning steps, starting from the AP profile (AP, Radios, Networking, and Ethernet attributes) and followed by the associated WLAN service profiles (SSIDs, Captive Portal, RADIUS, Passpoint, OpenRoaming, Mesh, etc.). The provisioning profiles are typically applied to all APs in a specific network location (such as a city, building, or floor, etc.) using a single-click operation. Profiles can also be applied to individual APs if required.

APs can be added to a specific customer location in bulk by importing a .csv file containing a list of AP identities, customer account IDs, and an associated AP provisioning profile.

Upgrading the AP firmware across the network is enabled by a sophisticated Upgrade Manager Cloud service. The latest AP firmware revisions can be deployed to specific network locations in an orchestrated approach to minimize interruptions to the service. Therefore, each Customer Network can be kept at the desired baseline AP firmware revision level automatically.

The inventory of provisioned APs for a given customer account can be viewed in the CIT Portal. The set of APs displayed on the UI can either be filtered by location or by specific AP Profiles, which allows for the rapid detection of provisioning anomalies.

The CIT Portal provides visuals of the deployed APs per a custom-defined logical location hierarchy. This is done by building floor plans and using Google-Earth geo locations. AP states are dynamically set and visualized on all location display types.

To facilitate the management of operational trouble tickets, the NetExperience SP Portal provides a fully integrated panel for opening and tracking these trouble tickets.

Floor plan heat map

The Self-Driving Network

One of the key benefits of the NetExperience Cloud Management and Controller platform is its ability to autonomously detect network operation anomalies and to automatically apply any mitigation actions as needed. For any cases in which these automated mitigation procedures are not possible, a set of intuitive troubleshooting insights are provided to the network operation team for further troubleshooting.

The NetExperience CMAP Hybrid Cloud-AP network optimization algorithms predict the max-per-user performance achievable per location given past and current trends of RF and packet exchange metrics. The Radio Resource Management algorithms will detect if the predicted network performance is below the expected levels and, if so, respond by applying time, radio, or location-specific mitigations in the form of real-time hitless configuration changes. The optimization parameters include the dynamic selection of primary and backup per-radio channels, the setting of radio RF parameters to ensure a balanced transmission and reception of radio cell size to achieve optimal location coverage and medium capacity, and the dynamic attachment of client devices to the radio link with the highest predicted performance.
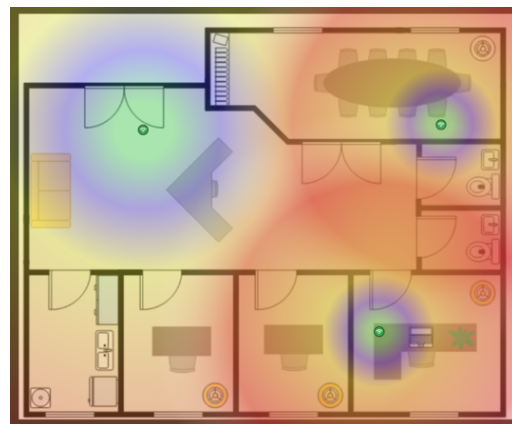
Additionally, past and current results of these automated mitigations can be viewed on the Portal UI.

Background RF measurment
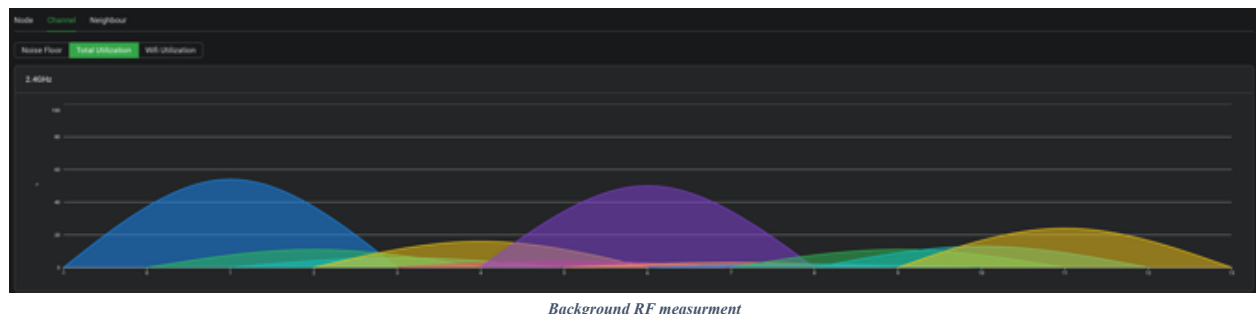
In any case where automated mitigations are not possible to be executed, a full troubleshooting panel is provided to the network engineer to perform a root-cause analysis for a client's low connection and Quality of Experience. These troubleshooting panels provide a historically-correlated set of client metrics and protocol events, thus allowing for fast root-cause analyses.

One Platform For Use In All Cases

The NetExperience Cloud architecture enables Wi-Fi SPs to use the same WLAN management and control solution for all their end customers' market verticals. This highly flexible architecture disaggregates and abstracts the required per-vertical feature sets from the specific AP hardware models.

Thus, a unified approach to network operation can be used for diverse market verticals that span from public Wi-Fi (hotspots) to private Wi-Fi (enterprise, education, health care, retail, hospitality, SMB, etc.).

Public Wi-Fi services can benefit from the wide range of Captive Portal (CP) technologies, such as Embedded CP, UAM External CP, XWF CP, and Social Media CP. The NetExperience solution supports Passpoint and OpenRoaming, which enables additional monetization options for Wi-Fi SPs operating in diverse geographic areas though their partnerships. NetExperience supports the full DNS-NAPTR dynamic discovery of the SP subscriber authentication servers.

The NetExperience Cloud Management and Controller platform allows for the easier control and management of nation-wide public deployments both indoors and outdoors via flexible location-based navigation features on the Portal UI. Customer account WLAN service activation can be automated from the existing SP Cloud platforms using the NetExperience Cloud REST APIs.

Private Wi-Fi usage cases are supported through a complete set of enterprise-grade features covering authentication and security (WPA3-Enterprise, PMF, RADSEC, RADIUS-Proxy, 802.11kvr, ACLs, etc.), advanced networking features (QoS, CoS, Tunnelling, VLAN, NAT, Access/trunk LAN control, LLDP, etc.), and automated high-density Wi-Fi optimization algorithms (auto channel and cell size RRM, client steering, automatic noise detection switching,

etc.). This feature set ensures operation at a high level of performance in critical mission business environments.

Emerging Markets For Open Wi-Fi

Lately, there has been significant market demand from several initial segments despite the overall lack of awareness of Open Wi-Fi. These segments fall broadly into one of the following categories:

- Mid-Sized Wi-Fi SPs:
  - The business model for mid-sized Wi-Fi SPs is demanding, with relatively low margins and higher OpEx than desired, due to the requirement to operate several platforms at once to provide a full suite of Wi-Fi services. For example, they may operate one platform for enterprise, a separate platform for hospitality, and possibly even a third for SMB. Thus, the ability to use one platform in all cases would result in a potentially significant OpEx reduction. The promise of a lower CapEx due to the availability of competing hardware APs would also help the overall business model.
- SPs In Developing Nations:
  - The budgets for SPs in developing nations are highly constrained. In the past, they simply could not afford to deploy Wi-Fi of any quality, if at all. Thankfully, Open Wi-Fi changes this paradigm by making high-quality, scalable Wi-Fi available to these SPs at low costs. Their end markets are typically in the domains of education, offices, hospitals, and public Wi-Fi. The availability of outdoor APs from one vendor, and indoor APs from another, is a major benefit as the most cost-effective hardware can now be selected for use in any given case.
- Large SPs In Developed Nations:
  - Although slower to reach the market than in either of the previously outlined categories, the world's largest SPs are keenly aware of the benefit that comes from eliminating vendor-lock. This attribute alone is enough for them to quickly bring Open Wi-Fi into their labs and to start field trials, with NetExperience participating in many of these trials worldwide.

For customers pertaining to any of the above categories, the end-user markets that emerge are primarily involved in the domains of hospitality, public Wi-Fi, and higher education. However, there are indications that the next major market to emerge for Open Wi-Fi will likely be MDUs. This is because the MDU environment is usually heavily polluted with RF, since each apartment broadcasts its own Wi-Fi signal at maximum power, which then results in major interference with all associated neighboring Wi-Fi. This is an example of a clear case where a sophisticated Cloud controller, such as the NetExperience Cloud Management and Controller Platform, would be a major improvement.

In summary, current market demand is exceptionally strong despite the lack of awareness of Open Wi-Fi. As this awareness is expected to rise in 2022 and beyond, this market demand will

subsequently increase rapidly, especially as many more examples and reference customers make themselves available for appropriate PR-related activities.

Next Steps

The NetExperience short-term product evolution of the Cloud Management and Controller Platform includes support for Wi-Fi 6E APs and a set of Cloud-managed AP switches. Additional CMAP applications have been planned in the coming releases, which include a more in-depth look into the analytics of customer-centric network usage, additional policies on a per-client basis, and advanced network security features. Furthermore, this research from NetExperience with the leading Universities in the area of Wireless Networks and AI Algorithms will continue to enhance all aspects of the CMAP-driven network automation process.

To get involved in this exciting new wave of WLAN market revolution, or for more information on the NetExperience solution set, please contact huw@netexperience.com.