INSIDER REPORT

TIP OpenWiFi—Unlocking Wi-Fi Potential
February 2022
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EXECUTIVE SUMMARY

A large portion of the world population remains unconnected despite huge progress made in the last two decades.

These gaps in connectivity happen not only between developed and developing countries, but also between urban and rural areas in the same country, and even within urban areas in the same city. Many factors explain the ongoing digital divide rendered more acute by the ongoing pandemic. These range from socio-economic to cultural to historical. In most cases, wireless is the quickest and most affordable way to reduce the connectivity gap, and Wi-Fi is the most economical wireless technology to deliver that connectivity.

Wi-Fi has seen much innovation spanning six generations of IEEE standards and five generations of WLAN architectures. Despite this evolution, service provider and enterprise Wi-Fi market, unlike 3GPP RAN, is held back by locked-in architectures between Wi-Fi controllers and access points and often between Wi-Fi controllers and the network applications that run on them. These proprietary architectures leave little room for service providers and customers to influence innovation outcomes resulting in higher costs of network upgrades and scaling. In other words the lack of openness is holding back the Wi-Fi market as a whole.

By disaggregating the hardware with the service, TIP OpenWifi promises to bring the benefits of software-defined networks into wireless networking. The Telecom Infra Project (TIP) OpenWiFi is an open source community project that believes in democratizing premium Wi-Fi experiences for multiple market use cases. The TIP approach to OpenWifi creates an open source disaggregated technology stack without any vendor lock-in.

TIP OpenWifi offers premium managed Wi-Fi features, local break-out design, cloud native open source controller, and an open source AP firmware operating system tested nightly.

TIP OpenWifi aims at disrupting the vendor-locked Wi-Fi infrastructure for service providers, deploying public and enterprise Wi-Fi. The benefits of TIP OpenWifi include:

- Lowering total cost of ownership
- Removing vendor lock-in
- Enabling new services
- Lowering barriers to entry
- Allowing one architecture for all Wi-Fi use cases
- Accelerating innovation—open-source technology, rich APIs, and new business models
- Giving operators and Enterprises a way to influence requirements and open source development through TIP

While we are still at the very early stages of market development, the initial case studies presented in this paper clearly demonstrate the huge potential in very diverse deployment scenarios and use cases. From a home user in developed countries to the Kenyatta University in Kenya... from a village in India with PM-WANI to a service provider in Germany... TIP OpenWifi promises to become the great enabler for connectivity and innovation.

We hope you enjoy this new insider report provided to you by Maravedis and Wi-Fi Now thanks to our sponsors.

Adlane Fellah, Senior Analyst
Maravedis LLC

Adlane Fellah, Senior Analyst
Maravedis LLC
In this interview Chris Busch, the co-Chair of the TIP Open Converged Wireless Software Project Group, talks about this year’s achievements of the TIP OpenWiFi initiative, and what we should expect from the ecosystem in the next year.

Please tell us about why TIP OpenWiFi was initiated and where it fits in the TIP family?

TIP has been enabling telecom ecosystems for several years now. This has led to greater choice, flexibility and innovation which have always been important and now even more so with numerous supply chain challenges we face as an industry. TIP OpenWiFi really began with many of the same ideas. We looked at the current industry of enterprise Wi-Fi systems where high quality, advanced features live today and noted significant vendor lock-in and a lack of any open standards that would permit supplier diversity and choice for the operator or end user. When considering the bulk of mobile traffic worldwide is carried by Wi-Fi systems, the idea to bring a premium managed Wi-Fi experience into a disaggregated and open source solution just made perfect sense as the next access solution available from a TIP community project group.

What are the most exciting features TIP OpenWiFi is working on?

We spent 2021 developing a new management and control plane for our stack that presents a hardened set of cloud managed features. Some of the most exciting features are surely the ability to handle mobile offload with full support of WBA OpenRoamingTM, additionally our local RRM and SON client steering that can run locally among the APs without need for cloud infrastructure. However, we should also note, TIP OpenWiFi has unlocked access to a number of Wi-Fi 6 and 6E platforms that previously were only possible with locked down software.

Some 24 different access points now run TIP OpenWiFi, rivaling the portfolios of many vendors at this point.

What can you tell us about the momentum TIP OpenWiFi is currently enjoying?

Our new 2.0 release has resonated with operators worldwide now in mobile offload, hotspot and venue connectivity including education and enterprise applications. We recently announced University deployments in Taiwan and Kenya, Hotspot deployments in India, a number of trials in the Americas and a new Cable MSO initiative.

How would you describe the level of collaboration between your participants?

TIP OpenWiFi has a great community of open source participants. We are over 100 companies and well over 400 individuals in the software group today. In 2021 we strengthened our code maintainer roles and also introduced a security maintainer auditing for each monthly release. We are now seeing active collaboration in the new Cloud SDK with participants working on microservices for unique features. Each week the development team meets in an Agile stand-up meeting to discuss the week ahead in addition to our bi-weekly software group team meetings. We are tremendously encouraged by these positive signals from the participants and look forward to increased product based focus in 2022.

What important lessons have you learned so far?

Unlocking Wi-Fi in hardware diversity terms to only replace with lock in and recurring cost above the Cloud SDK for key value features is not what operators or end users are interested in. We made our 2.0 system all about flexibility to deploy advanced features such as offload, roaming, channel management and mesh locally with scale for many of the most popular deployments in the 2-24 AP size network without requiring those features run in the cloud.

We also heard from a number of broadband managed service providers that scale and performance of provisioning which ultimately lowers operating cost was a central topic. The 2.0 release has exceeded expectations on this front, TIP OpenWiFi is now able to manage hundreds of thousands of devices through horizontal scaling independent cloud services.

Please describe your relationship with other industry bodies such as OpenWRT, Prpl, WBA, etc.

TIP OpenWiFi works with a number of leading and critical industry groups for Wi-Fi including OpenWRT, Wireless Broadband Association (WBA) and the Wi-Fi Alliance.

TIP OpenWiFi leverages the OpenWRT operating system for all TIP OpenWiFi devices. Since the start of the initiative TIP has taken great efforts to maintain an open and upstream system for its Wi-Fi software. Through close work with the OpenWRT community, TIP OpenWiFi has been first to deploy the latest OpenWRT management and telemetry known as uCentral.
OpenRoaming has been an important topic to TIP OpenWiFi. Early on in the program we enabled enhancements that make WBA OpenRoaming for mobile offload solutions possible from open source. We look forward to multiple market deployments from several trials underway specifically related to this WBA standard.

What would you say to those not currently familiar with the work of TIP OpenWiFi?

There are so many key industry roles who come into TIP OpenWiFi today. For the ODM looking for a complete software stack from which to offer innovation and open interfaces, or seeking silicon diversity or a wide range of indoor and outdoor platforms, there is a lot to enjoy here. Large incumbent and Managed Service Providers alike enjoy the flexibility of choice in platform, the removal of vendor lock in. Multiple vendors of commercial controllers can easily consume the TIP OpenWiFi SDK to open their existing cloud and managed solutions to include all the TIP OpenWiFi device families. Even the everyday open source developer has a lot to like in TIP OpenWiFi from embedded firmware to cloud micro services. We like to say in the project group ‘it’s a great day for TIP OpenWiFi’, so if you are any one of the mentioned roles or somewhere in between, we truly encourage you to join the TIP OpenWiFi community within the Open Converged Wireless software group https://telecominfraproject.com/openwifi/

Interestingly, India has the highest number of unconnected people, despite having the second largest online market in the world and that 50% of the country’s population still does not have internet access. China takes second place, with over 582 million people not connected to the internet. This is partly because of the country’s significant rural population; in 2019, 39% of the country’s population was living in rural areas.

There are various reasons why these regions have a high percentage of unconnected people; these range from political to economic to social. The lack of computer literacy and PC ownership are important causes, even if a great part of the population access the internet from a handheld device.
1.1.2 DIGITAL DIVIDE BETWEEN URBAN AND RURAL AREAS

People in rural areas continue to face greater challenges than people in urban areas—in terms of remaining connected during the lockdown, especially in developing economies. Large swaths of the rural landscape are still not covered by mobile broadband networks, and fewer households in these areas have access to the internet. Globally, about 72% of households in urban areas had access to the internet at home in 2019, almost twice as much as in rural areas (nearly 38%)\(^4\).

These comparably lower levels of adoption among rural residents may be due to a unique feature of rural life. Even though rural areas are more wired today than in the past, current infrastructure does not support consistently dependable wireline broadband access in many rural areas. This lack of reliable high-speed internet access has come to the forefront of discussions about navigating remote work and school during the coronavirus pandemic.

The urban-rural gap was small in developed countries, but in developing countries urban access to the internet was 2.3 times higher than rural access.

1.1.3 DIGITAL DIVIDE WITHIN CITIES

Low-income communities in urban areas face as significant a connectivity challenge as those in rural areas. When the pandemic shut down schools in 2020, it created a new urgency to narrow the digital gap in cities across the globe; millions of students who did not have internet access at home struggled to participate in remote learning. It also reinforced the reality that the divide doesn't just exist between rural and urban communities, but also within the world's largest cities, from New York City to New Delhi. For example, approximately half a million NYC households have no internet access, either because they cannot afford it or because it is not available.\(^8\)

Recognizing that the digital divide will persist after the pandemic, digital inclusion advocates say there is a need for more permanent solutions. Many municipalities and communities have begun to take things into their own hands by investing in broadband networks. City governments have provided the following initiatives: vouchers and subsidies to residents to purchase broadband internet, routers, and hotspot devices; expanded connectivity at facilities such as public libraries; and digital literacy training (among others).

While equipping homes with wireline broadband is typically the best technology, it is not the most economical or practical and few cities have the infrastructure ready. In the absence of an extensive network of municipal-owned cables, some communities are establishing mesh wireless networks to connect low-income citizens to free or low-cost internet using high-powered, long-distance Wi-Fi radios installed on tall structures to transmit internet. It is safe to say that TIP OpenWiFi will bring down the cost of the total solution, which will in turn drive the deployment of Wi-Fi in areas not economically possible before, thus reducing the connectivity gap previously described.

Another important driver for open networking is lower total cost of ownership and flexibility as we discuss in this next section.

1.2 SERVICE PROVIDERS WANT ONE STANDARDIZED PLATFORM

Service providers serve different market segments—from hospitality to higher education to financial institutions. Each market vertical is typically served with a different network hardware vendor, and service providers have to deal with separate proprietary switches, controllers, and cloud solutions that are incompatible with each other.
Typically, each hardware vendor provides a set of features and form factors tailored for a particular client, use case, or vertical. The result for service providers is a complex and rigid network which has several issues:

- Service provider must invest time and money to learn and train employees for each vendor platform for multiple vendors.
- Each vendor may or may not support new feature requirements from service provider who is at the mercy of vendor's roadmap and priorities.
- Introduction of new features and innovation are slower than in an open environment.
- Service providers are "locked" by each vendor and cannot mix access points from different vendors using a single controller, making switching vendors almost impossible.
- Service providers have to pay a premium to each vendor as hardware is not open which results in both higher OpEx and CapEx.

As a result, service providers have a fragmented influence on the pace and shape of innovation that affects their business. That explains why service providers want a standardized and open platform that delivers the same base functionality across vendors and platforms on top of which a new ecosystem will fast track innovation.

### 1.3 WI-FI SERVICE INNOVATION

Since the first Wi-Fi standard was released twenty years ago, Wireless Local Area Networks (WLANs) have become a dominant form of networking technology. Today, Wi-Fi is a critical and ubiquitous aspect of enterprises of all sizes and industries, furthered by the swelling usage of Wi-Fi-enabled BYODs such as smartphones, tablets, laptops, and IoT.

For many businesses, Wi-Fi is mission critical to operational success. While home users may (or at least used to) tolerate a Wi-Fi outage—albeit not without frustration—schools, hospitals, corporations, and many other organizations cannot. Enterprise network architecture reflects this criticality, as differing needs demand different solutions.

In fact, enterprises have been improving the architecture of their WLANs since their beginning, from when access points (APs) were the primary network element, to the current era of cloud management and distributed control. We've seen five generations of WLAN architecture, spurred by changing user needs and updated Wi-Fi standards and chipsets.

However, the pace of Wi-Fi innovation in the enterprise has been slow and dictated by the few largest equipment vendors, leaving little room for smaller companies to innovate and disrupt their established market. Each vendor invested (and continues to invest) large amounts of time and money into a common set of features, while little is dedicated to new ways of bringing differentiated features.

Innovation happens behind closed doors, and little is shared outside customers. That represents a tax on the industry as it is estimated that 80% of enterprise Wi-Fi features are common and provide no differentiation whatsoever. TIP OpenWiFi promised to change exactly that by removing the need to invest in the basic common features and make these open to all, leaving the space to invest only in value-added features.

### 1.4 AGE OF SILICON SHORTAGE

The global pandemic has aggravated an already existing pressure on the demand from materials needed to build radios, especially silicon. People working from home have needed laptops, tablets, and webcams to help them do their jobs, and chip factories did close during lockdowns.

However, the pressures facing the chip industry prior to the pandemic were one, the rise of 5G (which increased demand), and two, the decision by the U.S. to prevent the sale of semiconductors and other technology to Huawei. Chip makers outside the U.S. were quickly flooded with orders from the Chinese firm. As the pandemic unfolded, early signs of fluctuating demand led to stockpiling and advance ordering of chips by some tech firms, which left others struggling to acquire the components. Chip makers are responding to sustained demand by increasing capacity, but that takes time; it is estimated that the shortage will continue beyond 2022. TIP OpenWiFi can help alleviate the impact of silicon scarcity on ODMs, service providers, and consumers by enabling hardware vendors to use whatever silicon is available from a participating silicon vendor that is TIP OpenWiFi-compliant instead of being locked in to one single supplier. One platform can be used for multiple hardware vendors.

“TIP OpenWiFi has the potential to unlock extensive opportunities for both Minim and our customers. We have seen first-hand fragmented and proprietary router firmwares can slow down new product innovation.”

Alec Rooney—CTO, Minim
2. Challenges with the Traditional Approach

As indicated previously, Wi-Fi has seen much innovation spanning six generations of IEEE standards and five generations of WLAN architecture. However, most of the Wi-Fi infrastructure parts have remained proprietary to each vendor with little interoperability between vendors. While software-defined networks have long been implemented in data centers and computing, SDN in wireless networking is a relatively new concept, but things are moving fast now.

2.1 CLOSED ARCHITECTURES WITH VENDOR LOCK-IN

In the current Wi-Fi architecture, each vendor provides its own proprietary controller and access points and related proprietary software. A service provider will need to manage as many separate systems as vendors deployed in its network.

That means managing, learning, training, and improving each separate proprietary system independently of the others, thus increasing complexity and headaches for IT teams and putting them at the mercy of each vendor agenda and product roadmap.

TIP OpenWiFi solves this problem by providing service providers with the flexibility to mix and match access points from different Wi-Fi vendors under the same controller platform. Service providers can then select suppliers based on their differentiated offering—both at the hardware and software level—without having to worry about interoperability and vendor lock-in.

2.2 HIGHER INITIAL AND ONGOING COSTS

The lack of interoperability translates into higher costs for both the hardware and software. Each vendor invests in developing features within closed doors and other vendors do the same. These features are often common among vendors resulting from higher NREs and often result in little or no differentiation between vendors but are necessary for each solution to respond to basic market needs. By pulling together a common set of features, TIP OpenWiFi frees up development costs for each vendor. AP software is preloaded by the manufacturer and is ready to be provisioned and optimized automatically. Vendors can then focus on value-added and unique functionalities or on their superior implementation of the IEEE standards that customers value and are willing to pay for. As a result, TIP OpenWiFi promised to deliver a 10%-50% cost reduction, depending on the vertical, mix, and model and software included.

2.3 MULTIPLE WI-FI PLATFORMS FOR DIFFERENT USE CASES

Traditionally, Wi-Fi infrastructure vendors have been focusing on select verticals where they hold the greatest market share. Ruckus is well established in the hospitality sector, while Cisco and Aruba tend to dominate among very large enterprise clients such as banks or campus deployments. In the small business space, Cisco-Meraki and Ubiquiti have been leading the market with lower-end hardware. Therefore, the market is quite stratified, and service providers who support several industries and related use cases have had to deploy gear from different vendors. On the hardware front, each vertical may also require special form factors, thus adding to the complexity.

This approach is no longer viable for many service providers who want to support different use cases and verticals with the same platform. TIP OpenWiFi enables that.

Bernard Herscovici—CEO, NetExperience

"TIP OpenWiFi promises to disrupt the Wi-Fi market where vendor-lock and high CapEx and OpEx have limited worldwide market penetration. It is clear from the enthusiastic reception and acceptance by service providers across the globe that this promise will be fulfilled, and NetExperience intends to maintain its lead in delivering the best and most comprehensive cloud-based Wi-Fi management and controller solution."

Non-recurring engineering (NRE) cost refers to the one-time cost to research, design, develop, and test a new product or product enhancement.
3. Benefits of TIP OpenWiFi

3.1 REMOVING VENDOR LOCK-IN

TIP OpenWiFi removes vendor lock-in and lowers barriers to entry to develop Wi-Fi products. As we indicated previously, the common software stack enables different controllers to manage access points and switches from different vendors. It also reduces development costs and accelerates time to market for both cloud software OEMs and hardware ODMs. In particular, through its advanced feature set—including Wi-Fi 6, Passpoint, and OpenRoaming® capabilities—TIP OpenWiFi also makes it easier and more efficient to implement and offer enterprise-grade Wi-Fi products.

3.2 ONE ARCHITECTURE FOR ALL WI-FI USE CASES

TIP OpenWiFi offers service providers and enterprises a wide range of Wi-Fi cloud controllers and access points which bring more choice to the market. It also supports a multi-vendor interoperable deployment, making it possible to mix and match hardware, software, and controller providers. As a result, the business case for Wi-Fi connectivity is improved. In addition to all that, TIP OpenWiFi creates opportunities for additional efficiencies in network operations, including the potential to leverage machine learning algorithms through the strong automation tools incorporated in its feature set.

“TIP OpenWiFi is a joint approach of TIP participants to build a disaggregated Wi-Fi network and systems that will help the industry to accelerate the delivery of efficient and cost-effective solutions. SPs and ISPs will benefit from the ecosystem of hardware and software suppliers that reduces vendor lock-in and increases their flexibility.”

Vishwanath Angadi—VP, Strategy & Operations at Indio Networks Pvt, Ltd

“Our cloud controller software development team has developed an architecture using all the principles and ideas surrounding the use of open technology enabled by the TIP OpenWiFi initiative, and I am proud of the end-to-end product we have launched. I believe the world will rapidly adopt TIP OpenWiFi given the clear operational and cost advantages of this new technology.”

Marcel Chenier—CTO, NetExperience

3.3 ACCELERATED INNOVATION—OPEN SOURCE TECHNOLOGY, RICH APIS, AND NEW BUSINESS MODELS

TIP OpenWiFi is an open platform that empowers service providers and enterprises to develop their own private, cloud-based services. TIP OpenWiFi also helps technology suppliers to focus on their strengths by providing a robust Wi-Fi network infrastructure software platform. This makes it possible for companies to focus, innovate and differentiate on the very important network application layer. Access to the TIP OpenWiFi cloud controller SDK is based on standardized open north-bound APIs, so over-the-top Wi-Fi applications can be integrated once and then used with multiple vendor solutions, thus saving integration costs and reducing time to market.
API (Application Programming Interface) is a software interface that exposes the services and data of one application to the programmatic control of another. APIs facilitate the data and command interchanges between different programs and different tiers in a cloud-based solution. APIs are the digital glue that holds the applications and systems together.

In the Wi-Fi context, APIs enable the creation of an ecosystem consisting of the best-of-breed software solutions to develop around a platform. For example, as access point vendors focus on the infrastructure, they can integrate guest Wi-Fi analytics and monetization platforms for specialized software vendors, thus enriching the value of the integrated solution. APIs in the WLAN can be anything that is relevant to adding value to the WLAN architecture: IoT applications, location-based services, testing, big data, advertising, captive portals, etc.

3.4 SERVICE PROVIDER DRIVEN THROUGH TELECOM INFRA PROJECT (TIP)

With TIP OpenWiFi, service providers finally have a seat at the table to influence the development of the software stack and roadmap. Leading operators such as Deutsche Telecom, MTN, Vodacom, and others are already trialing TIP OpenWiFi and contributing to its development.

For the very first time service providers will be able to serve multiple industries—from hotel chains to hospitals and universities—with the same platform.

In Europe, Deutsche Telekom (DT), who also co-chairs the TIP Wi-Fi solution group and is active in building TIP OpenWiFi and defining its requirements, has kicked off trials at their labs in Berlin with plans for field trials in Darmstadt, Germany.

“The multi-vendor TIP OpenWiFi network, with its ability to mix and match vendors who are specialists in software services and hardware development, offers us the best of all world options for creating a competitive and cost-efficient Wi-Fi network to improve the experience for our residential customers, or, in enterprise environments either as a standalone network or complementary to cellular as part of a converged solution. As co-chairs of the Wi-Fi groups, we are very pleased to see the TIP OpenWiFi movement bring together the best of open-source community development with the rigor of good OEM product development practices.”

Daniel Brower—VP, Technology Business Operations, Deutsche Telekom

In Africa, MTN is evaluating TIP OpenWiFi as a cost-effective platform that can help close the business case for addressing multiple use cases for enterprise-managed services.

“MTN operates in multiple countries with varying business challenges. TIP OpenWiFi’s disaggregated architecture opens up opportunities to provide much needed flexibility to our enterprise clients. Along with 5G, W-Fi is an essential tool in our portfolio for meeting the needs of Africa’s digital future.”

Leanne Da Cerca—Senior Manager: Connectivity, MTN Group Enterprise

3.5 ENABLING NEW SERVICES

As explained earlier, vendors are able to develop a unique solution on top of the common software stack to support specific use cases and features. Example of solutions include better radio management services, network monitoring, optimization, analytics, marketing integration, or simply better implementation of IEEE amendments with superior algorithms.
Below is a table of differentiation features by a select group of vendors:

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<th>Vendor</th>
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<td>WLAN controller</td>
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<td>Advanced Wi-Fi features</td>
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<td>Indio</td>
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<td>IO by HFCL</td>
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<td>Policy &amp; Authentication services</td>
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<td>Minim</td>
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4. Features of TIP OpenWifi

TIP OpenWifi is a disaggregated Wi-Fi software system, offered as free open-source software, that includes both a cloud controller SDK and an enterprise-grade access point (AP) firmware, designed and validated to work seamlessly together.

The TIP OpenWifi platform enables the ecosystem to develop and commercialize connectivity solutions for advanced enterprise and service provider use cases more quickly and efficiently. In the TIP OpenWifi model:

- Multiple ODMs¹⁰ build a diversity of TIP OpenWifi-compatible whitebox access points, addressing different potential use cases. These devices incorporate TIP OpenWifi's firmware that integrates seamlessly with the TIP OpenWifi cloud controllers.

- Multiple Wi-Fi OEMs¹¹ build and commercialize solutions using the TIP OpenWifi stack, running on top of Whitebox Access Points. The open APIs of the TIP OpenWifi cloud controller make it possible for OEMs to offer value-added services (e.g. WLANaaS, security, UX, etc.) to these commercial solutions.

- Enterprises and service providers adopt these competitive Wi-Fi solutions to efficiently target critical use cases, like wireless internet, hotspot, roaming/offload, etc.

¹⁰Original design manufacturers
¹¹Original equipment manufacturers
4.1 FULLY DISAGGREGATED OPEN TECH STACK

The TIP OpenWiFi software tech stack is composed of the following parts shown in the exhibit below and incorporates advanced features, including open, standardized APIs and data models (AP & controller); scalable mobility & Wi-Fi meshing; extensible radio resource management (RRM); Passpoint (802.11u) and OpenRoaming; configuration, telemetry and analytics, and much more.

John McBrayne, Head of Product Management at Actiontec said, “As an indication of our dedication to the OpenWiFi community, Actiontec is perhaps the only equipment manufacturer developing state-of-the-art, purpose-built Wi-Fi equipment designed specifically for OpenWiFi. Our advanced tri-band Wi-Fi 6E API7340 was designed in close cooperation with the TIP community to ensure that every aspect of the AP is designed to operate optimally under the current OpenWiFi 2.x and future standards.”
TIP-supported access points represent available ODM/OEM platforms covered by standard automated TIP Wi-Fi testing with active firmware development. Access point providers include HFCL, Indio Networks, Edge-Core, and others and come with pre-integrated compliance. TIP OpenWifi devices ship from the factory with a unique device certificate signed by the Telecom Infra Project Certificate Authority.

AP NETWORK OPERATING SYSTEM (NOS)

The access point network operating system (AP NOS) is composed of three elements: the agent, the middleware, and low-level firmware and kernel. It is based on OpenWrt, extended with premium enterprise and service provider WLAN features exposed over a common data model and interface, using OpenSync including telemetry data but transitioning to uCentral agent (see roadmap in section 5.1 for details).

OpenWrt new management and telemetry model uCentral have been adopted for TIP OpenWifi 2.0. In this system, a single websocket exists per device to the cloud. TIP has developed Cloud SDK 2.0 as the reference point to validate compliance to both TIP OpenWifi 2.0 and uCentral.

4.2 MULTIPLE USE CASES—FROM RESIDENTIAL TO ENTERPRISE

Generally speaking, each vertical has their own hardware and features requirements. For example, hospitality may require different form factors and features which enable smooth onboarding of their guests, while MDUs would require a different set of features such as VLANs. TIP OpenWifi enables smooth integration of these particular features into the same

TIP Wi-Fi Access Point is a local breakout model with IP services and data plane occurring at the AP with management functions occurring through the Cloud SDK controller. Once initially provisioned, TIP AP may operate independently in the event communication is impeded with the controller. TIP AP NOS offers a base toolchain from which multiple supported target platforms will be built and tested.

CLOUD SOFTWARE DEVELOPMENT KIT (SDK)

The TIP Cloud SDK functions as a controller for TIP 802.11 Wi-Fi access points and provides abstraction of the physical access point from the northbound API consumer and is composed of these main elements: customer equipment gateway, database, storage, sets of microservices running on Kubernetes, and user interface.

A common data model is presented with uCentral southbound from Cloud SDK to TIP APs. Existing WLAN cloud vendors or other use cases may integrate with Cloud SDK northbound API for simplified access to all TIP Wi-Fi devices.

The Cloud SDK provides a set of open source software modules, enabling easy development of Wi-Fi enterprise network OAM applications by network operators and/or SaaS solution providers.

The main architecture goals are:
- Fully functioning and running software instance (not just a set of libraries)
- Provides all the essential services for target cloud NaaS implementation
- Includes gateway for metrics and provisioning
- Scalable time series processing to applications and databases
- Control back to OpenWrt network elements available to all applications
- Each component individually scalable
- No direct dependencies on any commercial cloud offering (i.e., full use of open source)
- Application implementation templates provided for advanced NaaS features
- Deployed as Kubernetes containers

Source: TIP

12 JavaScript Object Notation
13 Open Application Model (more at https://oam.dev/)
controller without having to do custom integration for each vertical and client thanks to the open nature of the technology stack. This creates huge savings in money and savings for ISPs and a protection of their investment as they onboard new clients from other sectors. In the case study portion of this paper, we look at case studies for education, village connectivity, and public venues such as malls.

4.3 ECO-SYSTEM DRIVEN DEVELOPMENT

All aspects of TIP’s OpenWiFi project are community-driven, with customer needs as the primary input for what gets built. The TIP OpenWiFi community empowers all stakeholders to participate and contribute. Everyone can see everything, including source code and nightly test results. This open collaboration model enables rapid development and release of customer-defined features, with no need to wait months/years for new releases from traditional vendors.

An ecosystem of 100+ service providers, software OEMs, and hardware ODMs has formed to develop, commercialize, and deploy TIP OpenWiFi based solutions including so far:

- 10+ service providers are trialing TIP OpenWiFi for use cases ranging from business Wi-Fi, venue hotspots, roaming/offload, personalized MDUs, etc.
- 5+ ODMs have shipped a diverse set of TIP OpenWiFi-compatible whitebox access points for indoor and outdoor use cases.
- 8+ Wi-Fi OEMs are leveraging the TIP OpenWiFi stack to build commercial solutions for WLANaaS, machine-learning-driven automation, advanced analytics, device security, etc.

“We are thrilled to be a part of TIP OpenWiFi’s ambitious projects of deploying open public hotspots that are making a commendable impact on bringing education, banking, jobs, and social services to previously underserved communities. With this first-of-its-kind Wi-Fi architecture framework, HFCL will judiciously carve its path towards seamless connectivity.”

Anuj Mago - AVP Sales, HFCL Ltd.

4.4 COMMERCIAL-GRADE QUALITY ASSURANCE

The TIP OpenWiFi project has applied the best practices of web-scale software development and the Wi-Fi OEM industry to deliver commercial-grade quality, including CI/CD14 software builds for all hardware platforms, DevOps15-managed release engineering, and community-developed automated testing. CI/CD introduces ongoing automation and continuous monitoring throughout the lifecycle of apps—from integration and testing phases to delivery and deployment.

TIP community labs include 20+ wireless traffic generators, tens of thousands of UE over the air, 802.11 features, layer 7 traffic generation, and VoIP/video. Labs include RF chambers, programmable turn tables, and attenuators. Tests are scheduled nightly and weekly, and results published accordingly.

Exhibit: TIP Community Lab—Wi-Fi Testbeds

“We at HFCL believe in constantly learning from our peers to serve the market dynamics. HFCL’s alliance with TIP OpenWiFi has made it possible for us to transfer and share knowledge effectively to offer community-driven connectivity with imperative innovative progressions. Being a part of TIP OpenWiFi Community will help us learn from various stakeholders and educate them simultaneously.”

Ashish Jain—Presales Head, HFCL Ltd.

14 Continuous integration, continuous delivery
15 DevOps is a set of practices that combines software development and IT operations. It aims to shorten the systems development life cycle and provide continuous delivery with high software quality.
16 SKU stands for “stock keeping unit.” It is a number (usually eight alphanumeric digits) that retailers assign to products to keep track of stock levels internally.
The community oversees and ensures that TIP OpenWiFi-based products are compliant with the software tech stack. Compliance testing includes:

- Each access point hardware SKU\(^{16}\) passes software capability testing.
- Cloud solutions can interwork with any TIP OpenWiFi-compliant access point.
- Software products properly implement the TIP OpenWiFi cloud controller SDK northbound API.
- Multi-vendor TIP OpenWiFi networks interoperate as expected (meshing, RRM, etc.).

### 4.5 GLOBALLY SECURE WITH ZERO TOUCH PROVISIONING

TIP OpenWiFi includes zero touch provisioning (ZTP) based on public key infrastructure (PKI) over the public internet—a key requirement for deploying disaggregated network systems in a secure way.

### 4.6 COMPATIBLE WITH OPENROAMING™

WBA OpenRoaming provides assurance that the Wi-Fi/cellular networks automatically interoperate with each other to deliver an automatically connected network experience, allowing users to securely roam from location to location without the need for logins, registrations, or passwords.

During 2020, the TIP OpenWiFi community started multiple OpenRoaming trials across the world. These include:

- In the U.S., Boingo and NetExperience, in collaboration with the Wireless Broadband Alliance (WBA), are trialing OpenRoaming using TIP OpenWiFi infrastructure.
- American Broadband, in collaboration with two Tier-1 U.S. operators, partnered with Edgecore Networks to conduct trials of the WBA’s Passpoint 2.0 and OpenRoaming standards.
- The TIP OpenWiFi gear was validated with Google’s Orion OpenRoaming service.

“The WBA worked closely with the TIP OpenWiFi community during the development of the TIP OpenWiFi platform to ensure that Passpoint and OpenRoaming were supported out of the box, ensuring standards compliance, ease of deployment and feature performance.”

Tiago Rodrigues—CEO, Wireless Broadband Alliance

### 5. Future Developments

The Open Converged Wireless project is a dedicated TIP community-driven open source software project for the design, development, and testing of converged indoor connectivity for Wi-Fi, small cells, and PoE Switching. The project will focus on developing deliverables that will cover whitebox hardware, embedded network software, and cloud native automation software, all well integrated.

### 5.1 TIP OPENWIFI ROADMAP

The main change occurring in 2021 for TIP OpenWiFi is the transition from Opensync middleware and agent to uCentral which was developed in partnership with OpenWRT and is a lighter solution (1Mb) than Opensync (50Mb). As described below, many features are introduced each quarter and tested on a constant basis. Improvements come from a combination of testing and making the current technology stack more robust as well as individual participants of TIP OpenWiFi.

\(^{16}\)SKU stands for “stock keeping unit.” It is a number (usually eight alphanumeric digits) that retailers assign to products to keep track of stock levels internally.
5.2 INTEGRATION WITH CELLULAR (5G, 5GNR, CBRS, ETC.)

TIP OpenWifi is working on the integration with cellular network under the hyperconverged wireless systems program with a vision to build a unified controller for Wi-Fi and cellular. The hyperconverged wireless initiative is part of the OCW project group and is a novel architecture for wireless deployments in buildings. The emerging consensus is that most enterprises are not willing to invest and manage two separate networks, and that for private LTE, CBRS, and 5GNRU to be adopted, they must be made compatible with existing Wi-Fi networks.

As shown below, the vision is to deliver both Wi-Fi and private 4G LTE/5G to a single set of radio heads with a unified controller for both cellular and Wi-Fi.

Source: TIP

6. Spotlight Use Cases

In this section, we look at a series of preliminary case studies for various use cases and environments.

6.1 FIRST COMMERCIAL TIP OPENWIFI SOLUTION IN AFRICA WITH NETEXPERIENCE

This deployment is a partnership between Atlancis (an open system integrator and cloud service provider in Kenya), the Kenyatta University, the Kenya Education Network Trust (KENET), and the National Research and Education Network (NREN) of Kenya. The deployment will use NetExperience cloud controller and access points from Himachal Futuristic Communications Ltd (HFCL) and Cambridge Industries Group (CIG).

Atlancis Technologies is a system integrator based in Nairobi, Kenya. It is an ISO-9001-certified company, a member of the Telco Infra Project and an Open Compute Project (OCP) Solution Provider. With a staff of fifty, the company is the first to deploy TIP OpenWifi on the African continent; their ambitious goal is to eventually connect ninety University campus sites across the country, starting with the Kenyatta University campus. The deployment will provide internet connectivity to over 75,000 students.

This will be the first time that a cloud-based open architecture Wi-Fi network will be deployed in Africa. “The main philosophy is the disaggregation of hardware and software, and TIP OpenWifi is an extension of what we have been doing using our own cloud platform,” said Paul Statham, Regional Commercial Director at Atlancis. The goal is to provide massive CapEx and OpEx savings to clients in networking as has been proven with data center clients in Kenya. The savings from commodity hardware will enable clients to focus on investing in differentiated development and market-differentiated software.

The Challenges of Traditional Networking

Atlancis has been working with traditional networking suppliers of access points and switches—such as Cisco-Meraki HP and Ubiquity—and has faced the well-known issues of vendor lock-in. Another important issue with these vendors includes the expensive yearly maintenance OpEx—ranging from training to replacing parts and renewing software licenses after the first year—amounting to an annual 10% of the initial CapEx investment. Those are high costs that put great pressure on the business case for cost-sensitive organizations such as universities. Replacing one vendor with another is a difficult proposition, given the lack of interoperability between vendors and the lack of transferability of training knowledge.

Another issue with traditional OEM software is that it is proprietary and locked to each specific vendor, while TIP OpenWifi API will enable local talent to develop local applications and boost innovation. Moreover, TIP OpenWifi offers the flexibility to consume the WiFi controller and management solution on a SaaS basis or as a licensed basis hosted within a local service provider data center.

The Promises of TIP OpenWifi

As an open and disaggregated network solution, TIP’s OpenWiFi confers a number of key benefits over current proprietary solutions that make them particularly suited to this kind of use case—such as deployment and automation-driven operational savings that reduce the total cost of ownership. In addition, enterprise and carrier grade features enable the provision of high quality, high capacity connectivity at scale, which is critical to delivering the kind of service that can meet the requirements and expectations of today’s student body.

In particular, the NetExperience licensing and support costs are affordable and predictable and result in a lower total cost of ownership. Training is provided on the cloud platform and is hardware independent. Interoperability between access point vendors means that the client organization can mix and match access points from different vendors resulting in more flexibility and better deals.

Atlancis projects a whopping OpEx reduction of 75% compared to traditional OEMs. Another important benefit of TIP OpenWifi is the access to a rich ecosystem of suppliers and innovators.
The NetExperience Cloud Controller
NetExperience provides a full suite of features as part of its cloud controller solution. Features range from Wi-Fi monitoring to optimization and ease of configuration. The company envisions that modules—such as the QoE (Quality of Experience) engine and automation—will provide huge operational savings to service providers in the long run. As the network grows, the ability to automate troubleshooting without human intervention can make a huge difference in the business case. NetExperience is working with a world class team of wireless networking AI and ML experts from the University of Ottawa to enhance and improve the current algorithms for optimization of network performance, root cause analysis, and automated corrective actions.

NetExperience’s customer success team provides ongoing support and training to help new clients become familiar with the configuration portal and the main features of the management solution with an option to dive into more complex features as required.

The Roadmap
The initial network deployment will start in a new build section of the main Kenyatta campus in Nairobi with a planned 200 outdoor access points from HFCL and CIG-Actiontec. With COVID restrictions, the university would like to ease student density in indoor areas and move some of the learning to outdoor areas. The new build consists of common areas and a number of student residences. Atlancis estimates that the initial network will be up and running sometime in January 2022, at which time network performance and other KPIs will start to be measured against the objectives.

Conclusion
TIP OpenWiFi promises to unlock connectivity in countries and network providers who simply cannot afford the traditional networking solutions and OEMs. The benefits of TIP OpenWiFi include not only lower total cost of ownership, but also the opportunity for local talent to develop solutions for the local market on top of a truly open world-class solution supported by a growing ecosystem. In this context, NetExperience provides a solid platform, easy to deploy, rich in features, available as needed, and with a clear return on investment. This is just the start of a networking revolution.
6.2 MTN

MTN Group Limited is a South African multinational mobile telecommunications company, operating in many African and Asian countries. As of December 2020, MTN recorded 280 million subscribers, making it the largest mobile network operator in Africa, and the 8th largest in the world. Active in twenty-two countries, one-third of company revenue comes from Nigeria alone where it holds about 35% market share.

Context
MTN is highly interested in the overall TIP OpenWifi promise of lower TCO (total cost of ownership) and flexibility in network vendor choice. While enterprise connectivity is a relatively new business for MTN, it is seen as a promising segment. The demand for public Wi-Fi is high in African markets, but deployments have remained modest as there has been no clear way to monetize these expensive public hotspots. For example, MTN has few public Wi-Fi deployments in malls in South Africa and Ghana, and similarly on university campuses with older generation Cisco and Ruckus equipment. TIP OpenWifi promises to change these economics and enable the scale-up of hotspots in a sustainable way.

Proof of Concept
MTN is currently testing TIP OpenWifi-compliant controller and access points as well as contributing to the TIP roadmap and milestones. From a business strategy, MTN is in the process of defining its go-to-marketing and product strategy, defining the product requirements, targeted segments, and types of solutions.

Use Cases
MTN predicts TIP OpenWifi to unlock a series of use cases not currently possible with traditional networking equipment vendors due to high licensing and maintenance costs. Those use cases range from targeted marketing to offloading traffic in high density indoor areas (such as shopping malls) as shown in the exhibit below:

![MTN Wi-Fi Market Segments](source: MTN Group)
TIP OpenWiFi promises to open several markets, from very small businesses to large enterprises:

- **Entry level solution**
  - Cost effective Wi-Fi router with guest wi-fi and monetization
  - VPN Lite solution for market entry into managed networks

- **Mid-sized business**
  - Seeking Wi-Fi coverage with limited features and a sparse number of users
  - Basic support features to detect network issues and failures

- **Retailer**
  - Guest Wi-Fi, marketing, and analytics
  - Security and user quality of experience that is affordable
  - ROI achieved through analytics, in-store experience, and targeted marketing

- **Public**
  - High capacity and density of users
  - Quality of connectivity and ability to seamlessly roam between networks and providers
  - Monetization platform and network segmentation as key use cases

- **Large enterprises**
  - Digitation and network convergence as a leading use case for large enterprise customers
  - Orchestration and unified policy management for WAN, LAN, and DC
  - Integrated campus switching with WLAN

**A Multi-Phase Strategy**

During phase 0, MTN is focusing on building a business plan and go-to market strategy based on lowering the total cost of ownership and building a flexible network foundation.

In phases 1 and 2, MTN is putting together specific solutions for the retail and healthcare sectors as well as smart buildings. Wi-Fi becomes the connectivity solution for IoT sensors and applications. Features being considered include monetization platforms, captive portals, guest Wi-Fi, and OpenRoaming.

In phase 3, MTN will be integrating Wi-Fi with its mobile core and interworking with 5G. The goal is both to manage radio technologies from a common core and enable a seamless transition between Wi-Fi and cellular.

**Conclusion**

MTN’s vision is that Wi-Fi is not just a data access technology, but also a digital enabler for multiple use cases and applications. TIP OpenWiFi promises to be a more viable solution for indoor coverage and connectivity than small cells. Thanks to its open nature and ecosystem, TIP OpenWiFi makes networking more affordable and open to innovation.
6.3 CONNECTING INDIAN VILLAGES WITH HFCL

About PM-WANI
PM-WANI (Prime Minister’s Wi-Fi Access Network Interface) is the Indian government’s ambitious project that aims at connecting the entire population of the country by deploying millions of Wi-Fi hotspots across India. To ensure the success of this program, the government has even waived off any licensing requirements which otherwise were mandatory for anyone who intended to offer any kind of internet services. The PM-WANI framework envisages provision of broadband through public Wi-Fi hotspot providers and consists of elements such as Public Data Office (PDO), Public Data Office Aggregator (PDOA), App Provider, and Central Registry. (More at https://pmwani.cdot.in/wani)

With the PM-WANI model, it is easy to deliver Wi-Fi services at the grassroots level, ensuring seamless broadband penetration across especially rural areas which are poorly connected. ISPs no longer need to pay a substantial fee for obtaining and maintaining an ISP license. The program wants to bring opportunities for small or village-level entrepreneurs while propelling socio-economic development in rural India.

The Test Village
With a population of 6,000, Baslambi Village is located in Farrukh Nagar Tehsil, Gurugram in Northern India, and is in the vicinity of HFCL’s manufacturing plant. Due to poor connectivity infrastructure, the village’s inhabitants have never before experienced seamless connectivity.

To give residents a taste of high-performing broadband internet, HFCL joined hands with its service partners to build a brand new Wi-Fi network based on TIP OpenWifi. These partners include: VVDN technologies for the hardware; i2e1 core as the Public Data Office Aggregator (PDOA) which provides the captive portal and authentication; and NetExperience controller tested in parallel with HFCL’s own controller.

The Deployment
An IO team of experts ascertained areas like schools and hospitals where people aggregate and make good use of the internet. The idea was to set up a high-speed P2P wireless link from the nearest ISP fiber PoP (6 km away) to provide backhaul connectivity to the entry point in the village. From this point, the connectivity was distributed over HFCL P2P and P2mP links. Here, the IO team did a run-down exercise of a complete Wi-Fi coverage model for smooth functioning. HFCL offered an enticing Wi-Fi package for all users where the internet could be accessed free of charge for six hours from one mobile with no limit on data download. After the time limit, the user would have the opportunity to either pay for the service or disconnect until the next day.

So far, fifty-three access points based on various versions of TIP OpenWifi have been deployed in the village and are managed by both HFCL and NetExperience controllers.

The Challenges
A number of problems had to be solved to ensure a proper quality of experience for the users. Those included:

- Power supply availability has been a real concern in Baslambi Village. HFCL installed solar panels at many places to power its equipment. The highest level of power efficiency ensures 24-hour operation even if there is no grid power available.
- Distribution of broadband internet to the entire village and other access points was a hurdle. However, HFCL’s team of experts tackled those challenge with its P2P and P2mP radios.
- To provide maximum coverage, all the equipment was to be deployed outdoors. Hence, HFCL-IP67-rated radios and access points designed for rugged weather conditions were used for such a deployment.

The Results
Initially, the data consumption recorded was merely 2GB per day. However, over a period of five months, the data consumption is >250 GB on an average per day, with approximately 2,500-3,000 unique users utilizing the services daily. The exhibit below shows the metrics currently monitored by the controller.
Most of the data consumption is from video, YouTube, Zoom, Netflix, web browsing, digital India services (banking and government citizen services), and predominantly from handheld devices but with some laptops (5-10%) and tablets (10%).

**Education**: As a result of COVID, students are still attending school from home (online classes and exams), and teachers are teaching from home, conducting seminars, etc. Thanks to robust TIP OpenWiFi, teachers can provide instruction from an empty classroom by streaming live. Even when kids come back to class, teachers have become accustomed to using online materials. The government of India has distributed laptops and tablets to students all over the country.

**Telemedicine**: Doctors provide online consultation to villagers.

**Entertainment**: Apps such as Netflix, Hotstar, YouTube, etc. provide a plethora of options for family entertainment.

**Banking**: Online banking has become the norm even in the most remote areas and among the most impoverished parts of the population. The pandemic has accelerated the use of apps such as Google Pay and Paytm, even for street vendors who now have adopted payment with a simple QR code.

**Other Use Cases**: There are many other use cases enabled by a reliable broadband network, from digital payment in road tolls to the use of wireless sensors for irrigation in smart agriculture.

**Conclusion**
TIP OpenWiFi has the potential to bring millions out of poverty and limited opportunities by enabling low-cost yet reliable connectivity in the poorest and most remote areas of India and elsewhere.

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**Sponsors’ Profiles**

**HFCL**

**About HFCL and TIP OpenWiFi Engagement**
HFCL Limited is a leading technology enterprise engaged in manufacturing of high-end Transmission and Access Equipment, Optical Fiber, Optical Fiber Cables (OFC). It is specialized in setting up a modern communication network for Telecom Service Providers, Railways, Defense, Smart City, and Surveillance projects.

The Company has state-of-the-art Optical Fiber and Optical Fiber Cable manufacturing facilities at Hyderabad, Optical Fiber Cable manufacturing plant in Goa, and its subsidiary, i.e., HTL Limited at Chennai, along with FRP Rod manufacturing facility in its subsidiary at Hosur. It also has a telecom equipment manufacturing facility at Solan. The Company's in-house Centre for Excellence in Research is located at Gurgaon & Bengaluru and invested in R&D Houses and other collaborators at different locations in India and abroad to innovate a futuristic range of technology products and solutions. Some of the newly developed products through R&D are Wi-Fi Systems, Unlicensed Band Radios, Switches, Electronic Fuses, Electro-optic devices, Cloud Management Systems, and Video Management Systems.

IO Networks, a division of HFCL Group, was conceptualized with the vision of creating affordable digital connectivity, opening “Infinite Possibilities” for all. What makes IO different is the depth and breadth of intelligent Wi-Fi mobility products and solutions that are feature-rich, provide the highest performance, and yet are exceptionally affordable, offering global citizens a chance to have a connected, digital life with limitless opportunities.
Its extensive range of products includes Access Points, Unlicensed Band Radios, Managed Switches, Power Solutions, Antennas, Cloud Network Management System, and Element Management System.

With its collaborative efforts with TIP OpenWiFi, IO Networks has laid a revolutionary Wi-Fi network infrastructure at rural villages of India, majorly benefiting the locals. The outdoor public Wi-Fi network uses TIP OpenWiFi based Access Points, P2P radios, solar power over Ethernet devices, and other network equipment to bring 24x7 broadband Internet connectivity to the residents. These deployments have transformed the way people communicate, perform business, make transactions, and perceive the Internet for 15000+ residents.

IO Networks has utilized TIP OpenWiFi’s network disaggregation capabilities, which has empowered local village level entrepreneurs to select Access Points from multiple vendors and connect onto an existing Wi-Fi network run by a network provider. This has dramatically reduced barriers to entry for new suppliers, increased the size of Wi-Fi market and enabled local suppliers to participate in reaping the benefits of bringing connectivity to unserved areas.

IO Networks has actively participated and contributed to the TIP OpenWiFi community, constantly learning and sharing knowledge with other involved stakeholders.

IO team is acutely aware that digital connectivity is a lifeline for remote communities. IO will continue to deploy essential networks to ensure connectivity for all.

With TIP OpenWiFi, HFCL will be able to offer high-capacity connectivity at scale, making the best use of its robust access solutions to maximize impact and serve its purpose of providing Internet connectivity for all. Empowering local populations by democratizing premium Wi-Fi services worldwide, we believe HFCL will set new heights.

Sandeep Kumar Chawla – AVP Wi-Fi, HFCL Ltd

Their commitment is to work relentlessly in this field until every citizen, even in the remotest part of the world, is connected seamlessly and cost-efficiently bringing “Infinite Possibilities to grow and thrive for the unconnected”.

INDIO NETWORKS

Indio Networks Private Limited, (formerly Wifi-soft Solutions) is product-based company having its offices in Austin, (Texas, USA), Sharjah (UAE) and Pune, Bangalore (India) is building next-generation connectivity solutions in TIP OpenWiFi, Wi-Fi6, IoT, 5G and LPWAN technologies. Indio Networks has been serving the WiFi industry for over 15 years in 45 different countries. It offers full-range of Wi-Fi access points, network access controllers, wireless cloud orchestration and management platform and WiFi hotspot solutions.

Indio Networks has been an active contributor to the Telecom Infra Project (TIP) OpenWiFi community and has recently launched TIP powered Wi-Fi Cloud Controller and Management platform called UWiOS for Enterprises, SMB and MDU Markets. Indio’s TIP OpenWiFi solution will be fully compatible with any TIP-enabled Wi-Fi access point thus allowing customers a choice of hardware platforms that fit their specifications and budget. Indio has successfully completed field trials of TIP OpenWiFi powered Wi-Fi 6 APs.

Indio’s UWiOS platform comes integrated with full hotspot management capabilities while supporting third party platforms like Facebook Express WiFi and India’s PM-WANI hotspot framework.

The TIP OpenWiFi project, driven by a global base of operators, managed service providers, vendors and industry organizations, makes it easy for vendors to optimize or reduce their R&D spend, specialize in their innovation and offer a new breed of interoperable enterprise-grade Wi-Fi solutions across cloud services and cutting-edge hardware access points. This in turn offers service providers, a greater choice of competitive suppliers from across the globe, to choose from. Together, this new ecosystem driven initiative from TIP will contribute to reducing the total cost of ownership (TCO) and faster implementation of next generation Wi-Fi networks.
Qualcomm Technologies, Inc. has joined TIP OpenWiFi initiative with a common goal of accelerating the pace of development and broadening the deployment of open, disaggregated, and standards-based connectivity solutions. TIP OpenWiFi is offered as a free open-source software that integrates both a Cloud SDK and an enterprise-grade service provider access point firmware that will reduce the total cost of ownership for service providers and MSPs, driving adoption and opening up new markets.

As part of this engagement, Qualcomm Technologies is delivering open-source upstream Wi-Fi drivers: “Ath10k” (for Wi-Fi 5), “Ath11k” (most current version for Wi-Fi 6), and platform solution for Wi-Fi 6 and Wi-Fi 5 access point and router. Qualcomm Technologies’ platforms are known for high performance and cutting edge Wi-Fi technology that is widely deployed across the service provider, retail, and enterprise market. The same platform is also powering many of the platforms built and offered by the TIP ecosystem. Qualcomm Technologies is also working with the TIP OpenWiFi developers, ODMs, and community participants to advance TIP OpenWiFi solution.

Sohail Ahmaed, CTO of Indio Networks said, “Utilizing the TIP OpenWiFi system has provided Indio’s engineering team with a shot in the arm, helping us scale and boost our Make in India product development initiatives. TIP’s disaggregated, feature-rich platform and automated testing cycles enable us as an OEM, to focus our development and testing resources on our key differentiating features, to gear up to raise global competitive benchmark. We are pleased to announce our commercial Wi-Fi platform built on TIP OpenWiFi system”.

Looking ahead, Qualcomm Technologies is working closely with the TIP community to identify future requirements that will pave the way for the next generation of platforms supporting Wi-Fi 6E and Wi-Fi 7 and to continue to drive innovation within the industry.

Minim, Inc. (NASDAQ: MINM) is on a mission to make home and office Wi-Fi safe and supportive for everyone. We deliver intelligent networking products under the globally recognized Motorola brand through partnerships with retailers, service providers, and enterprises. Our motosync app (powered by Minim) gives parents, remote workers, gamers, and streamers incredible superpowers to make the most out of their connectivity.

At the core of Minim is an AI-driven cloud platform that fingerprints, monitors, and optimizes all the connected devices in the home. Since the beginning, Minim’s platform was built with open source and open standard technologies. Now partnered with over 140 ISPs, Minim has joined the TIP Open Converged Wireless (OCW) Project Group to accelerate innovation and to make smart, secure Wi-Fi accessible to underserved communities.

Minim and TIP OpenWiFi participants have been evaluating the use of Minim’s embedded agent as part of the TIP OpenWiFi framework, making it easy and affordable for ISPs and OEMs to deliver a better-connected experience worldwide on any TIP OpenWiFi device.

The NetExperience Profile
NetExperience is a software company based in Ottawa, Canada that has developed a full WLAN management and controller solution for the TIP OpenWiFi initiative. TIP OpenWiFi enables the deployment of disaggregated networks by using hardware running open-source software from multiple low-cost vendors managed by a single cloud-based management system.

NetExperience is a contributor of the TIP opensource Cloud SDK and access point software in addition to providing a full commercial WLAN controller. In addition to management of TIP OpenWiFi, NetExperience supports the Wireless Broadband Alliance OpenRoaming framework and has been leading OpenRoaming trials with service providers around the world.

The NetExperience Platform
The NetExperience platform is designed and tested to work with any hardware vendors’ TIP OpenWiFi compatible access point. This enables service providers to avoid “vendor lock”
and also means deployments can mix and match different vendors’ access points, picking the best access point for the use case. This substantially reduces the initial capital costs compared to current solutions.

The NetExperience Platform is also designed to support multiple Wi-Fi use cases. No longer do you need to have a separate platform for SMB, education, hospitality, enterprise, and more; the platform supports all these use cases resulting in lower operating costs for the service provider.

One of the most advanced and innovative components of the software is the artificial intelligence based Quality of Experience (QoE) engine. After many years of development, NetExperience will incorporate a full AI engine to automatically detect and correct errors and performance issues. As connectivity or performance issues are detected (simultaneously for any client connected to any AP), the QoE engine responds by applying known good fixes, such as channel changing, cell resizing etc. The engine then measures the result and reinforces the action if it proves to be successful or backs it off if it does not result in any improvement. In this way the system learns for every client attached to every AP what the best approach to solving the issues are. A major benefit of this approach is the reduction in alarms sent to human support personnel, further reducing the operation costs for the service provider.

The NetExperience Platform also supports OpenRoaming as defined by the Wireless Broadband Alliance. The addition of OpenRoaming will allow Wi-Fi service providers to offload their users’ data needs directly onto the Wi-Fi network seamlessly without requiring user logins. For the cellular service provider, this is a significant benefit as their own networks are stressed by fast growing, high speed data traffic, often resulting in poor experience unless they can offload traffic to Wi-Fi. For the mobile consumer, OpenRoaming is a great user experience because without the need to login to a local Wi-Fi network, the traffic simply finds the best available path.

NetExperience’s Wireless LAN controller is available on a software as a service (SaaS) basis or, for large service provider installations, a licensed basis. The platform includes hierarchical portals with varying degrees of control and management of the entire system. The end customer’s IT team portal has the ability to manage their own installation; the MSP portal can manage all of their assigned customers; and the platform team—which may be NetExperience on a SaaS basis or the service provider on a licensed basis—has control over the entire system. The solution also includes iOS and Android apps for easy installation and zero touch provisioning.

NetExperience provides support for the entire solution, both software and hardware, giving its customers peace of mind that support is available from a single source.

### ACTIONTEC

Established in 1993, Actiontec is a North American based company delivering solutions for service providers and has R&D centers in Santa Clara, Taiwan and China. The company is focused on providing managed customer premise equipment for service providers. With multiple award-winning products — including Optim Managed Service Platform, Gigabit Ethernet fiber routers, high-speed VDSL gateways and home networking solutions — Actiontec products are deployed by some of the largest telecom carriers in North America. With more than 75 million connected home devices shipped to date, Actiontec is one of the largest CPE suppliers in North America.

Actiontec’s products have been widely adopted by leading Tier 1 and Tier 2 Service Providers in North America, including Verizon, CenturyLink, Google, Frontier, Telus, Comcast, Time Warner, Bright House, Cox, Charter, Dish, TDS Telecom, Bell MTS, Sasktel, and many others.

With extensive expertise in developing Wi-Fi devices, Actiontec provides a wide range of advanced TIP OpenWiFi Access Points, including indoor and outdoor APs for both enterprise and residential applications. This includes the cost effective Wi-Fi 6 2x2 API7220, an advanced Wi-Fi 6 4x4 API7241, and all the way to the upcoming tri-band Wi-Fi 6E APO7320, which is designed for outdoor 6GHz operations.

In addition to developing TIP OpenWiFi equipment, Actiontec’s groundbreaking Optim Managed Service Assurance Platform enables service providers to remotely manage, diagnose, optimize, and secure home networks. With Optim, families can enjoy fast, reliable and safe Internet throughout the home, while providers can improve customer loyalty and lower operating costs.

Combining decades of expertise in Wi-Fi equipment design and manufacturing and expertise in Wi-Fi cloud management platforms, Actiontec is dedicated to providing a comprehensive suite of TIP OpenWiFi solutions to meet the current and future needs of enterprise and service providers.
METHODOLOGY
Sources used for this paper include, among others, national statistical offices, city statistical offices, national telecom regulators, city department websites, internet usage or adoption surveys, and other sources such as the International Telecoms Union (ITU), the United Nations, and the World Bank.

How to Get Involved
There are multiple ways to consume, deploy, and contribute to the progress of TIP OpenWifi. You can download the open-source software for free and evaluate it in a lab; you can engage with a commercial vendor building solutions with the platform; and you can also actively participate in the community and contribute to the progress of the project. (See “Getting Started with TIP OpenWifi” for more details.)

How to Contribute to TIP OpenWiFi
The TIP community develops TIP OpenWiFi as an open-source product within the Open Converged Wireless project group which is open to all companies. This project group hosts weekly standup calls and monthly development sprints that are open to all companies that have signed a TIP participation agreement. The Open Converged Wireless group is chartered to expand the TIP OpenWiFi stack to include small cells and switching for a fully converged indoor wireless system. Sign up here to join the weekly calls and contribute (no participation fees!). Please contact us at TIP for further information at https://telecominfraproject.com/openwifi/

How to Participate in TIP’s Wi-Fi Solution Group
The TIP Wi-Fi solution group collaborates with the TIP OCW software project group in advancing the vision for open multi-vendor interoperable networks. The Wi-Fi solution group defines implementation-agnostic business scenarios and operator use cases for Wi-Fi networks. The community then builds solutions to address these use cases, leveraging the TIP OpenWiFi platform. These solutions are tested and validated against the solution group requirements and listed on the TIP exchange marketplace, including badges reflecting their level of compliance to the requirements. The tests use the TIP OpenWiFi lab test template document produced within the WiFi software groups (SG) They include the validation of the interoperability of the different TIP OpenWiFi-based elements that integrate the solution, including products from different vendors across hardware access points, controllers, captive portals, and over-the-top applications in a lab environment.
ABOUT MARAVEDIS
Maravedis is a boutique wireless infrastructure analyst firm founded in 2002. Maravedis focuses on broadband wireless technologies with a particular focus on Wi-Fi and IoT as well as industry spectrum regulations and operator trends.

Our mission is to research, analyze and provide guidance on the role of unlicensed technologies in the overall connectivity space.

ABOUT WI-FI NOW
Wi-Fi NOW is the world’s only media, event, and advisory organization dedicated to the Wi-Fi industry.

Since 2016, Wi-Fi NOW has served hundreds of Wi-Fi industry organizations from every corner of the diverse industry including vendors, manufacturers, service providers, resellers, and more. Wi-Fi NOW is the undisputed leader in dissemination of Wi-Fi industry news and information and today serves a readership of close to 20,000 subscribers and followers.

Wi-Fi NOW was founded by current Wi-Fi NOW CEO & Chairman, Claus Hetting.

Adlane Fellah, CEO Maravedis
afellah@maravedis-bwa.com
+1 305 865 1006

Claus Hetting, CEO & Chairman Wi-Fi NOW
claus@wifinowevents.com
+45 2534 1705