

AWARDS CASE STUDY: BEST IN-HOME WI-FI NETWORK

AMBEENT – UNLOCKING THE DIGITAL POTENTIAL

— VIRTUAL CONTROL AND OPTIMIZATION OVER NETWORKS WITH COLLABORATIVE, USER CENTRIC, & ZERO INTEGRATION FEATURES —

INTRODUCTION

Cloud-driven network environments and rising consumer expectations are driving telecommunication providers and enterprises to rethink their network monitoring and management strategies. Lacking effective management tools for this new paradigm, Internet Services Providers (ISPs) face high operational costs stemming from ineffective or lengthy service center support calls and costly “truck rolls” for on-site service, and possible customer churn. At the same time, traditional enterprise networks are hard-pressed to adapt to new realities of cloud computing, user mobility and remote collaboration.

Ambeent delivers deep visibility, highly contextualized management of networks and digital experiences in hybrid environments helping telco providers and enterprises build the network of tomorrow. An innovator in wireless technologies with over 20 patents filed to the USPTO, Ambeent does not just monitor and diagnose problems, it fixes them. Ambeent delivers the industry’s first cloud-based Wi-Fi spectrum optimization technology and an extensive toolkit for fault or incident management and resolution, resource management, network parameter tuning and modification that helps clients substantially improve end-to-end service performance and add value to their services.

In this case study, we introduce Ambeent’s digital experience and network performance monitoring platform with Wi-Fi spectrum optimization and diagnostics functions. We examine challenges of operates to provide cost-effective, superior services to their subscribers including specific user scenarios based on customer complaints. We also underscore emerging network demands amid the Covid-19 crisis, including work-from-home arrangements. We introduce technical features of Ambeent’s solution and how they apply to client needs. Finally, we address the broader impacts of Ambeent’s technologies on the telco industry as well as the economy and society at large.

DESCRIPTION OF THE CASE

In today's highly competitive markets the challenge for operators is to become more agile and differentiate themselves by offering customers seamless digital experiences and flexible services that meet the demands of their enterprise customers. However, high quality and reliable broadband user experience is hampered by Wi-Fi network quality, with service providers faced by endless subscriber complaint calls, high customer churn and low average revenue per user (ARPU).

Visibility to monitor networks, to diagnosis problems on the spot and make effective, remote interventions is a high priority for telecom operators. Unfortunately, operators lack effective tools to efficiently evaluate subscriber Wi-Fi QoE. They are unable to diagnose and solve Wi-Fi-related issues from a distance or to differentiate Wi-Fi-related degradations from other causes of poor customer experience. Likewise, subscribers are typically unable to resolve their Wi-Fi issues on their own and have to contact their service providers. For service providers, this lack of customer inability to solve Wi-Fi problems results in high operating costs stemming from ineffective service, and CPE (Customer Premise Equipment) replacement. Accordingly, due to the aforementioned lack of effective tools to diagnose and solve Wi-Fi-related issues, operators' attempts are frequently ineffective. This leads to many return calls and visits, generating higher levels of customer dissatisfaction.

Ambeent promises to boost the competitiveness of telecom operators delivering deep visibility, highly contextualized management of networks and digital experiences in hybrid environments. Improved visibility together with AI enables proactive customer care for operators to predict disruptions in the network and troubleshoot problems before their customers are affected. As a result, they can significantly enhance customer experience (CX) as well as achieve lower operating costs associated with lengthy tech support calls, truck rolls and unnecessary equipment returns as well as reduce their customer churn.

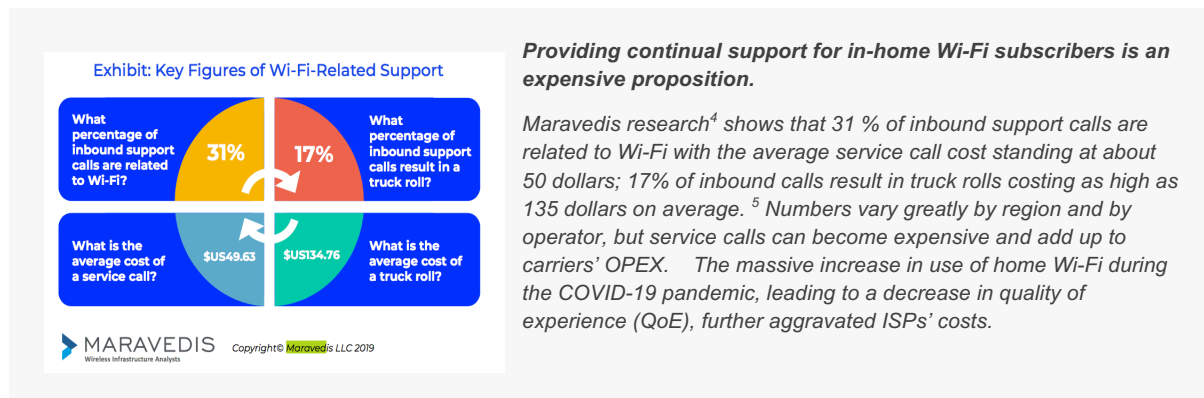
According to an EY industry study, 68% of senior industry executives cite customer experience (CX) as their top strategic priority followed by cost control and network upgrades¹. A study by the Drive Revenue with Great Customer Experience 2017 on 13 different industries, shows that telecommunications along with automotive and hotels can generate the most

¹ https://www.eyjapan.jp/industries/telecommunications/knowledge/pdf/2015-09_Global-telecoms-study_v14-en.pdf

revenue gains from improving CX². According to McKinsey, 76% percent of telco subscribers prefer a digital-only customer service compared with 57 % who prefer traditional channels. In turn, moving to digital could reduce call centre volumes and operating expenses by 25-30% for telecom operators.³

CLIENT-NEEDS:

In-Home Wi-Fi – network performance visibility and optimization: Operators A and B approached Ambeent with a primary concern to reduce technical support costs. Operator A receives Wi-Fi related calls from 5-6% of its customers monthly and more than 50% of these calls cannot be solved due to lack of data. About 15 % of customer complaints result in expensive truck rolls. Similarly, Operator B reports that 30% of customers who contact its call centre and/or online processing facility, report technical problems. Of those complaints, at least 50% relate to in-home Wi-Fi speed problems. Based on the findings of B's customer support teams, Wi-Fi data rates reported by the customers compared with downstream internet speeds measured at the modem output are, in most cases, much lower. Under such circumstances, changing the modem channel significantly improves this speed discrepancy, which clearly is an indication of interference with other users utilizing the same channel.



Ambeent promises to deliver the following benefits to its clients:

- **Enhanced customer experience and satisfaction:** 80 % -100% improvement in baseline Wi-Fi performance
- **Lowering of operational costs:** 25% drop in service calls with spectrum management and automatic access point configuration
- **Smarter Wi-Fi:** Optimal Wi-Fi performance outcomes regionally and for each individual user device in the home

²<https://www.forrester.com/report/Drive+Revenue+With+Great+Customer+Experience+2017/-/E-RES125807>

³ [mckinsey.com/business-functions/mckinsey-digital/our-insights/how-telecom-companies-can-win-in-the-digital-revolution](https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/how-telecom-companies-can-win-in-the-digital-revolution)

⁴ In its annual industry report, Maravedis conducted an extensive survey on home Wi-Fi issues. The online survey took place during the September and October 2019 timeframe and gathered 218 responses, 42% of which were from service providers worldwide.

⁵ Source: *Managed Home Wi-Fi Networks for the Smart Home 2020-2025*

Furthermore, with Ambeent solution, operators' technical teams can carry out context-aware interactions with their customers when they contact their service centres. Operators can predict disruptions in the network and troubleshoot problems before their customers are affected. The AI engine provides smart recommendations for incident resolution that are based on historical data of customer incidents and their assigned solutions. Ambeent collects and correlates data on networks conditions and end-user behavior allowing clients to profile subscribers and predict possible customer complaints. Clients can take action and trigger a *smart ticket* before their subscriber issues a complaint to their call center.

Operator A experienced quantifiable benefits after implementing Ambeent's solution including:

- **Increase in subscriber uptake of Operator A's application:** The number of subscribers that use Operator A's app increased from about 20,000 to about 280,000 after integrating Ambeent's Wi-Fi optimization technology into the app (Figure 1)
- Average improvement of 52 % in baseline performance by reducing neighborhood interference (Figure 2)
- Average link speed improved by 280% (Figure 3);
- Average Wi-Fi speed improved by 400% (Figure 4) (also see Figure 5 for data on customers that experienced the highest performance gains).

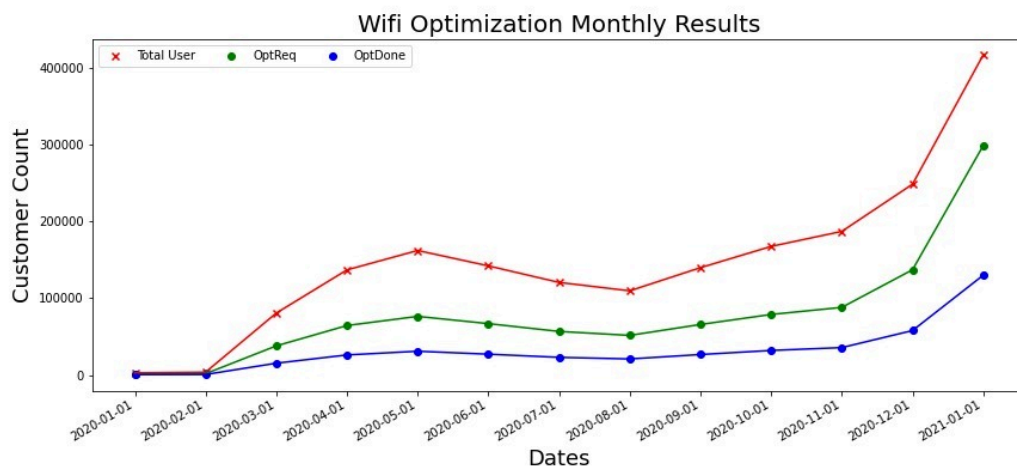


Figure 1 The number of subscribers using Operator A's app increases after implementing Ambeent's solution

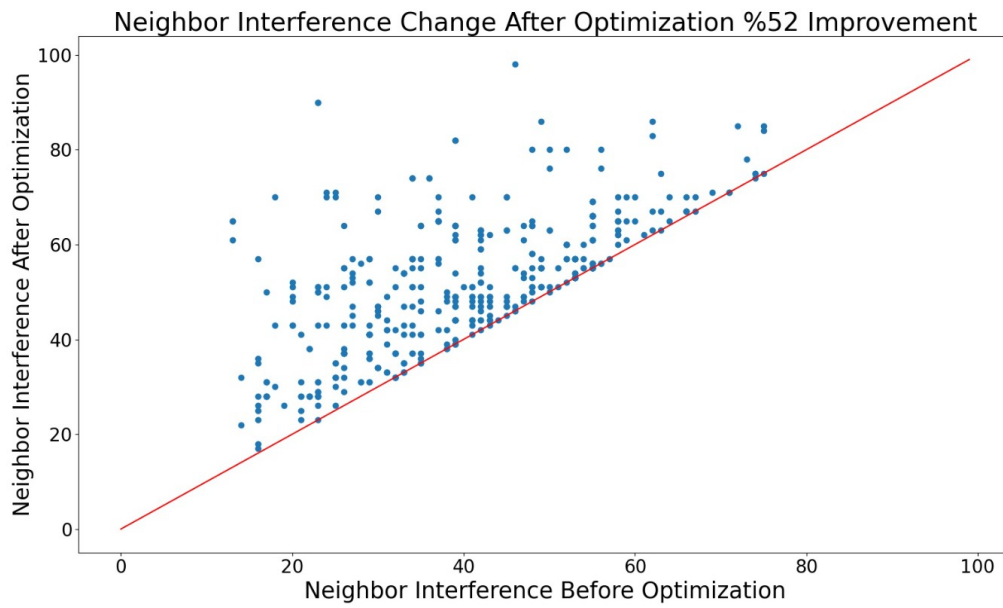


Figure 2 Neighbour interference improvement of selected Operator A subscribers after Ambeent's optimization

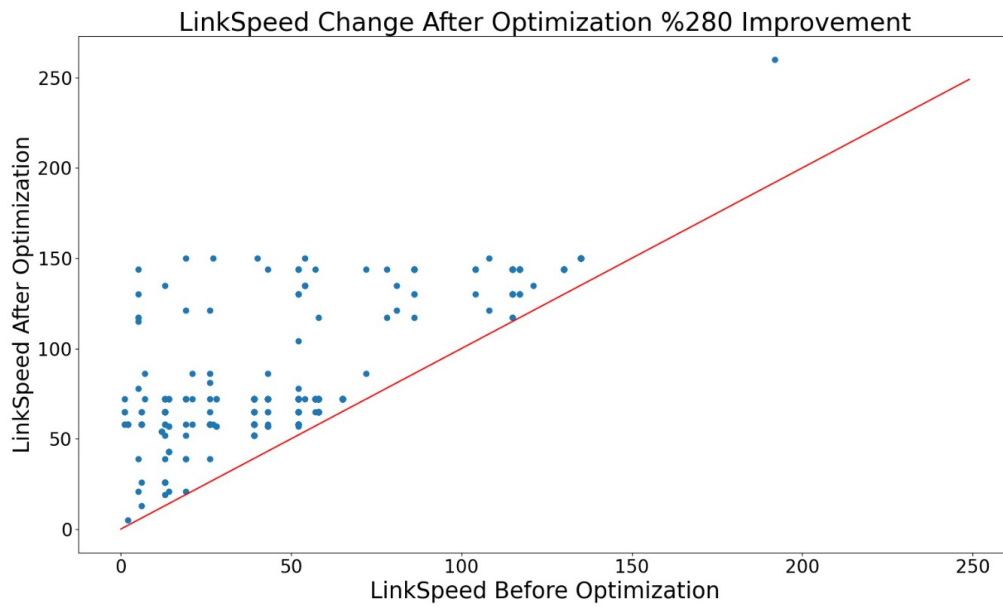


Figure 3 Link speed improvement of selected Operator A subscribers after Ambeent's optimization

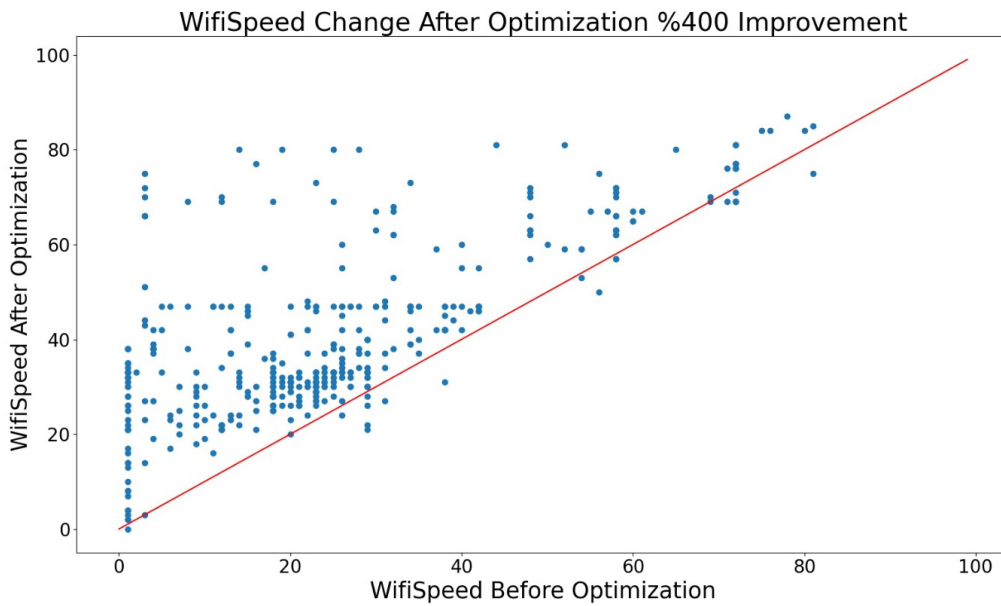


Figure 4 Wi-Fi speed improvement of selected Operator A subscribers after Ambeent's optimization

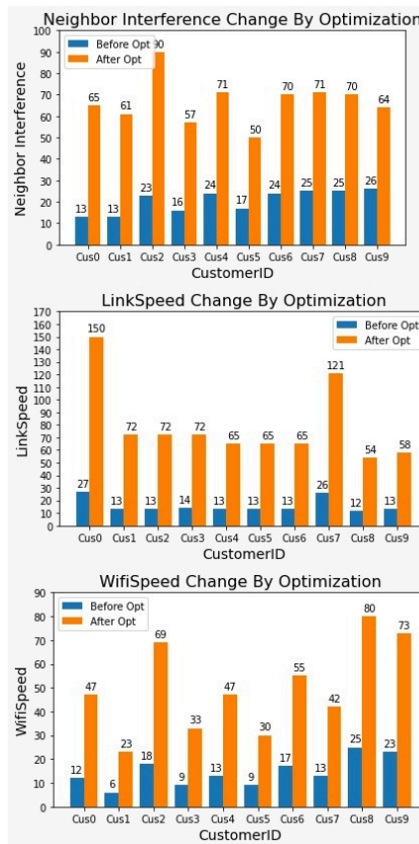


Figure 5 Subscribers which experienced the most improvement with Ambeent optimization

Enterprise networks –network performance visibility: Operator A needs documented proof that it is delivering QoS agreed upon in its service level agreements with its enterprise clients. A, would like a detailed view of how its clients are experiencing the network to ensure that it meets its SLA commitments. Operator A also views proactive network diagnostics as part of its customer-relationship management strategy to boost customer satisfaction and improve its brand.

Work-from- home: Companies of all sizes are impacted by the changes that are the result of the COVID-19 pandemic and are investing in technologies necessary to operate a tele-workforce. With Ambeent’s solution any company can track the Internet performance and connectivity of their employees that are working from home. Moreover, companies can leverage Ambeent’s application-aware optimization feature to prioritize mission critical applications, such as business calls, over other users in the home, for instance, trying to stream movie on Netflix.

Ambeent centralizes all client networks– for those on-premise or beyond a network’s perimeter - in the Cloud. It provides companies a secure tool to have remote access to their networks and to enforce exceptional service levels for their remote workers using in home Wi-Fi. Its ability to work with existing hardware and software technologies and its very low-cost structure also makes it suitable for small to mid-size enterprises. **Ambeent unlocks the digital potential for enterprises of all sizes.**

USER CASE SCENARIOS

Scenario 1 – User Activity-Based Optimization: The peak increase in Wi-Fi usage during Covid-19 showed vulnerabilities of the network, especially in congested household environment, and there is no prioritization mechanism.

For example, a student, Lucy, is a remote student. She has a 9am class presentation and is worried about her internet connection. With the current settings, Lucy is unable to guarantee her presentation will not be interrupted if another member of her household member simultaneous downloads a large file. What if Lucy could set priorities for her computer?

Ambeent's optimization framework can thoroughly optimize the traffic with respect to Lucy's computer and location in the house. This will ensure there is no interruption or dropping connection due to other individuals' internet usage in the home. Similar examples can be further elaborated to work related presentations, or watching a 4K video etc.

Scenario 2 – Neighbour Interference: In Scenario 1, neighbours are also involved.

Ambeent prioritizes Lucy's application and allocates her an interference free channel during her class presentation.

As shown in the Figure, by having the device and thus the user scan the immediate channel conditions instead of relying on a centralized gateway, the system is much more precise and dynamic. If, for example, the user is using channel 6, and walks to the kitchen where the neighbour also uses channel 6, the algorithm will tell the device to move to another channel, such as channel 11.



Scenario 3 – Lucy's smart TV has an Internet issue. She calls the customer service helpline of her operator. She is frustrated with the call center's script, which is coming in blind. The call centre then cannot identify the exact problem. They suggest sending a technician to the home.

With Ambeent's solution the call centre can immediately inform Lucy about the issue, indicating the internet connection speed over the past week, identifying non-optimal modem location, or neighbourhood interference issue. Ambeent provides an optimal solution, such as finding an alternative location for the router, recommending an equipment replacement, etc. Everything is simplified. Users are better informed and can find a solution without being frustrated. ISPs can reduce call centre costs and increase profit margins with more satisfied customers.

Scenario 4 – An employer, Sam, is the manager of a SME. Due to the Covid-19 pandemic 80% of his 50 employees are working remotely. More than half of his employees have been experiencing Internet connection problems during meetings.

Ambeent utilizes the SME employee's app by integrating its API. It provides Sam's IT team actionable insights into remote worker Internet experience and allows them to remotely troubleshoot problems of home-based workers.

SOLUTIONS

Ambeent's AI/ML powered mobile application (or SDK integrated into an application owned by an ISP client) and its Cloud environment where smart data is drawn together & analyzed delivers proactive and real-time optimization of networks and infrastructure for end-users, enterprises and ISPs.

The solution consists of the following elements:

- 1- Ambeent Cloud-Native Wi-Fi Spectrum Optimization.
- 2- Ambeent Digital Experience Monitoring
- 3- Ambeent Synthetic Performance Diagnostics and Forecasting for Network Monitoring and Optimization
- 4- Ambeent Network Planning and Validation

Ambeent allows for clients to analyze the characteristics and behaviors of Wi-Fi users and their connected devices, and the Wi-Fi environment leveraging a detailed dataset that no other vendor can provide.

- The Ambeent Smart-WIFI SDK collects relevant data from the end-user device, routers deployed in indoor/outdoor locations as well as from neighboring devices by scanning RF channels when in monitoring mode.
- Ambeent's user-centric data is particularly valuable in instances where data taken from the router is not able to provide accurate information on end-user digital experiences.
- Moreover, patented technologies allow the Ambeent SDK to remotely communicate with and access any router to collect relevant data, change channels, implement tools such as parental control, device blocking etc. without having to download firmware into the router.

Having a deep knowledge of the Wi-Fi environment, for instance, of a single home, local or regional groups of homes/offices, etc. enables our clients to add essential value to their ecosystem. In this regard, Ambeent can provide the following unique feedback on home and office Wi-Fi networks to clients:

- Information on router (AP) placement (e.g. optimal spot for AP location)
- Location of blind spots in the home
- In-home end-user motion analysis
- User behavior (e.g. traffic type, data consumption rate, connected time, etc.)
- Neighboring interference and channel information (used to characterize the architectural setting of the home with respect to neighbor interference)
- Odd behavior analysis including device-specific connection issues, frequent log ins and log outs, power cutoffs, router restarts, etc.)
- Rouge device detection i.e. new access points in the vicinity or devices slowing down performance
- Room by room statistics for signal strength, usage pattern, consumption rates, etc. (grid views applied for hotel clients that can be implemented in the home)

Ambeent also provides a unique toolkit focusing on channel optimization, fault or incident management and resolution, resource management, and network parameter tuning and modification to optimize the QoE of service delivery.

- Channel optimization - Ambeent has developed special metrics based on multiple variables including historical data on neighboring routers, usage patterns, data rates, etc. to carry out optimization at appropriate times (which is also determined via intensive analytics). Optimization can be automatic or manual depending on user preference
- Automated RF band/channel selection with user-side heatmaps
- Automatic band allocation for better performance and load balancing among different RF bands and APs,
- Cloud services for backup and restoration of key historical user data on network/infrastructure elements,
- Ad-Hoc Wi-Fi sharing tool to increase AP coverage increase,
- App based guest device control (for hotels, etc.)
- User / device -based bandwidth allocation technique
- App-based proactive ticketing
- QoS/QoE scoring based on daily/weekly performance for individual subscribers or for a group of subscribers.
- On-demand testing to help end-users manage/tune network infrastructure for better network performance during specific events
- AP rating system assessing the performance of APs and making user devices connect to the AP that will give the best connection

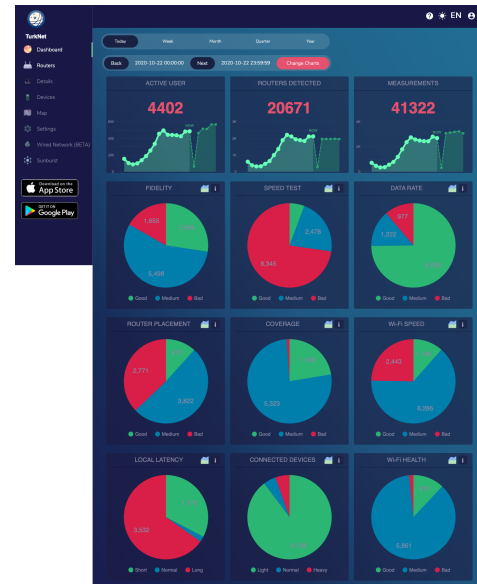
Ambeent delivers a wide range of features that may be provided by other digital experience and network monitoring platforms. Its user-centric data and AI-powered analytics engine can also complement features provided by these platforms and include the following:

- Device / user / home -based coverage analysis
- Device-centric Received Signal Strength Indicator
- Other measurements & statistics with intensive AI/ML include neighboring SSIDs, speed test results, latency, packet loss rate, jitter, buffer rate, CPU, RAM utilization, AP brands, OSs used, etc.
- Historical data analysis with intensive AI/ML
- Most preferred / connected servers to report user preferences/behaviors
- Average, or time specific number of hop counters to analyze their subscribers' potential traffic and latency demands.
- Average / time specific number of connected/active users for a high-level view of how crowded the AP is at a given point in time or will be in the future
- Routers (AP) detected, also used to predict future trends in the RF environment
- Connected / unconnected devices (their brands, OSs) in home and their behavior for detailed analysis of device behavior
- User customization through the mobile app
- User / home -based data consumption statistics
- User / home -based app and traffic type usage
- User / home -based available bandwidth and supported data rate
- Speed tests from a device to specific servers to fully understand congestion values at different locations, at different times.
- Wi-Fi Speed, also used to determine poorly performing devices on the network
- In-depth traffic flow analysis
- Automatic device blocking and unblocking without having to access the router
- App-based alerts and actionable recommendations provided in simple English
- Smart Troubleshooting with subscriber behavior identification and classification into well-known trouble-shoot problems to predict whether a subscriber is likely to complaint or not.
- Connected device monitoring and analysis, including IoT devices, sensors, cameras etc.

The Ambeent Dashboard: Key Performance Indicators (KPIs)

Ambeent provides in-depth knowledge of digital experiences and networks, leveraging advanced AI/ML. Visibility and control across large-scale networks are provided via a single and unified console, which is customizable. AI/ML also solves the cost of troubleshooting the many potential connection problems that can occur from many possible sources. **Ambeent's solution is the first Wi-Fi network monitoring and diagnostic platform to bring together user-centric, vendor agnostic, hardware-free elements:**

- Any network can be monitored and optimized without deployment of expensive customer premise equipment (CPE) or software licenses;
- It is interoperable with all types of equipment and services;
- It is a end-user-device-managed platform with the simplicity of an application installed in the user device. Thus, combining both the power of cloud-based computing and AI.



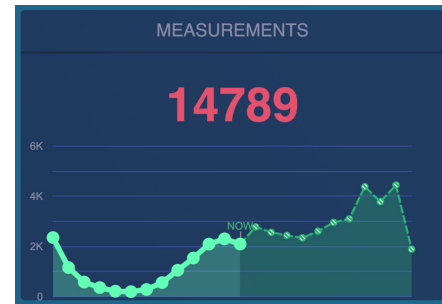
Ambeent's solution is cost-effective and interoperable, connecting systems and platforms, which were previously unable to connect.

The **Client Dashboard** shows key data and indicators collected with Ambeent including the following:

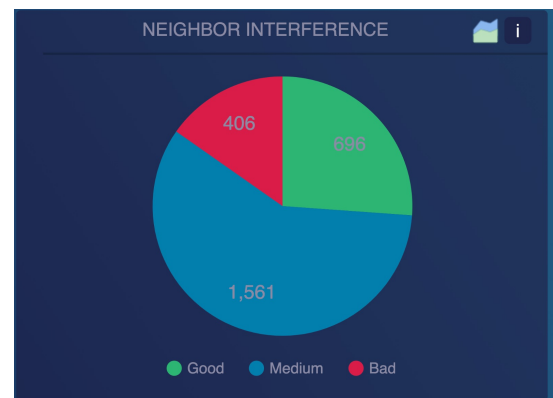
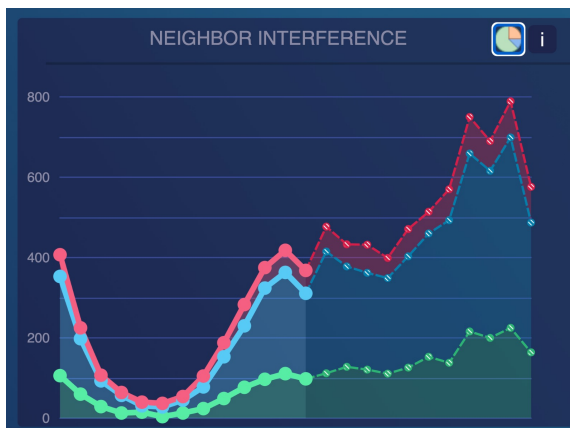
Active Users represent the number of devices that are active in the network. This metric provides a high-level view of how crowded the network is at a given point in time or will be in the future (AI/ML implemented).

Routers (AP) Detected represents the number of neighboring SSIDs (service set identifiers) that the application detects through the scanning of neighboring access points. This can be a good indicator of how busy the RF environment is (or will be) in a given area and a period of time. It is also used to predict future trends in the RF environment (AI/ML implemented).

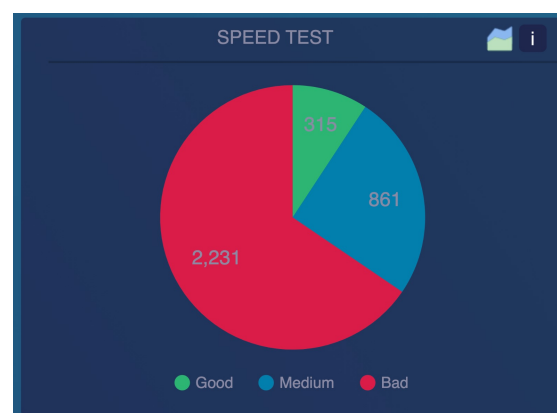
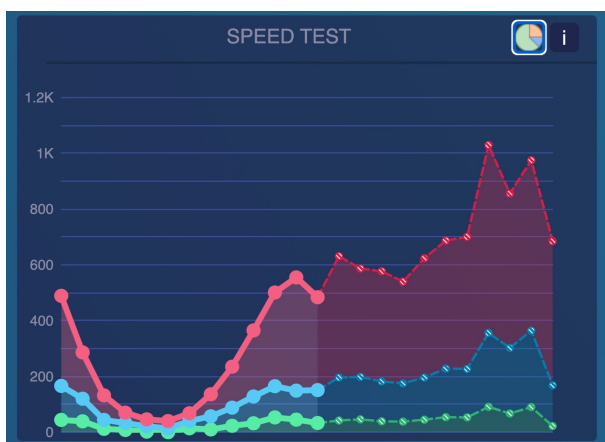
Measurements are the number of scans sent to the cloud, including neighboring SSIDs, speed test, latency, packet loss rate, jitter, buffer rate, CPU, RAM utilization, etc. KPIs can be shown in granular detail for each layer of the digital supply chain – device, local network, SaaS application, etc. depending on client preference. Right now, the Console is kept simple to make it easy to navigate.



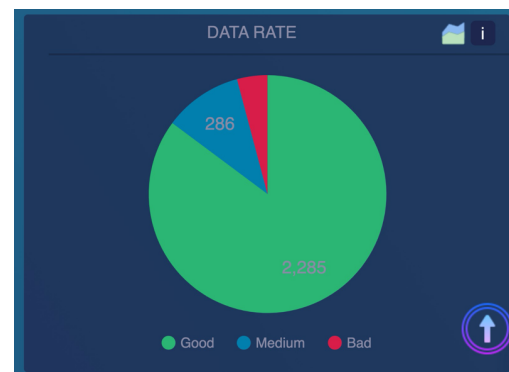
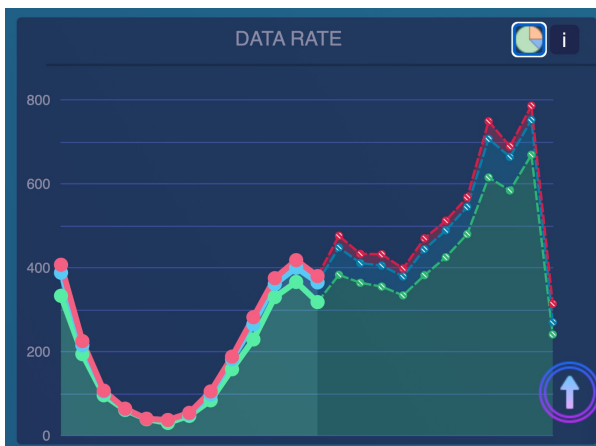
Neighborhood Interference is based on Ambeent’s unique formulation of the signal-to-noise ratio (SNR) and signal-to-interference plus noise ratio (SINR) and compares the level of the Wi-Fi signal to the level of neighboring interferers. This unique formulation allows us to characterize the architectural setting of the premise with respect to neighbor interference and delivers collaborative and optimal channel assignments among access points in a given vicinity.



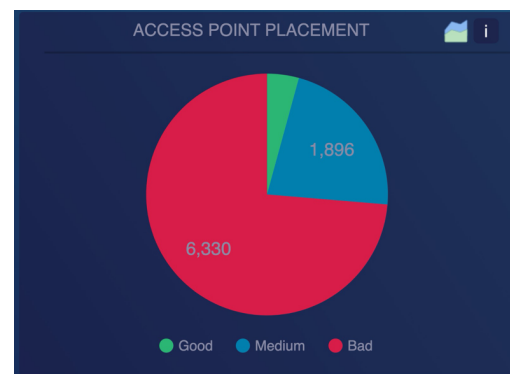
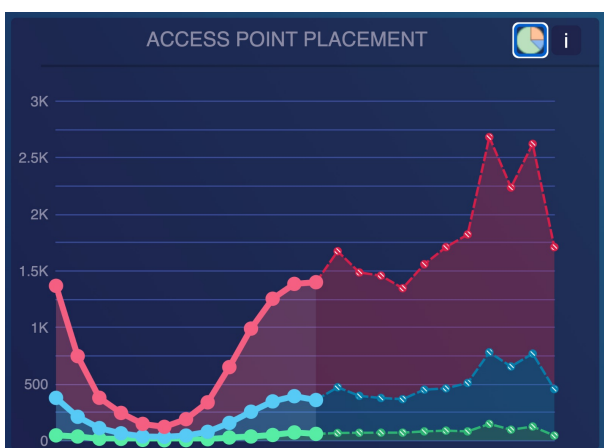
Speed Test measures the end-to-end throughput from the end-user device to various specific servers deployed on the Cloud. This allows clients to fully understand congestion values at different locations, at different times.



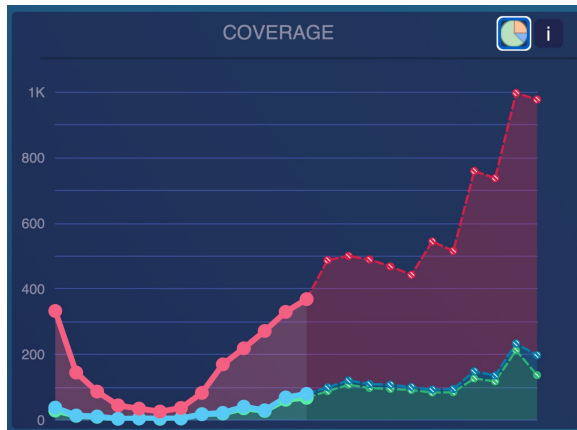
Data Rate provides the link layer rate (theoretical value) that the end-user device is allowed to transmit data at a given instance. However, in the real world, there will be interference and losses which will result in a lower bit rate. The throughput can be seen as a practical value that the wireless link can achieve. This data is used to monitor and forecast data rates over time, which is useful to see and optimize bandwidth usage. It can help clients plan infrastructure needs with a view to minimize costs without comprising QoE. Similarly, real-time and proactive data rate monitoring can help ISPs offload data traffic (i.e. between wireless and wired) with respect to peak hours towards increasing QoE.



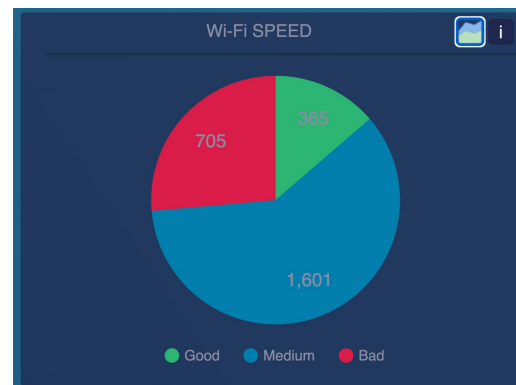
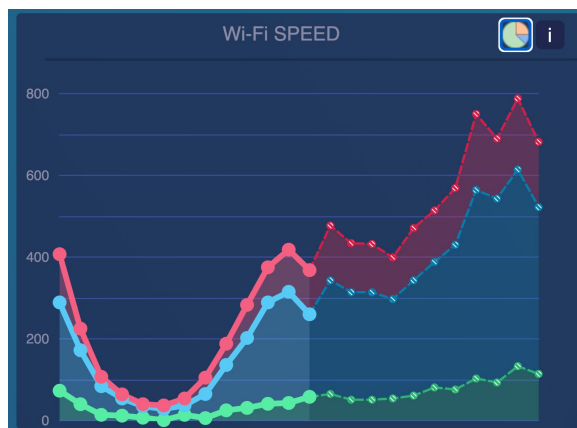
Router (AP) Placement is how well the router (CPE – Customer Premise Equipment) receives its signal. This is an indicator for how well the router is placed based on the received signal strength (RSS). It can provide information on the number of subscriber complaints stemming from inadequate AP placement. It can help a swift and successful installation of the home gateway or help subscribers and technicians find the best location for the AP.



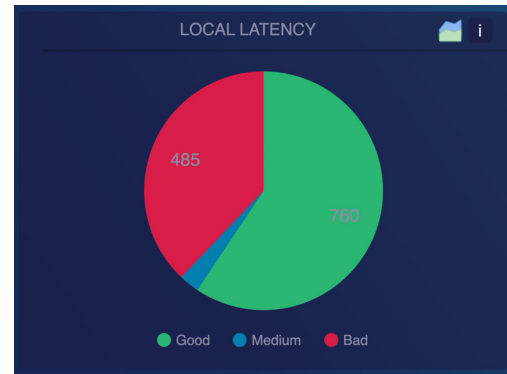
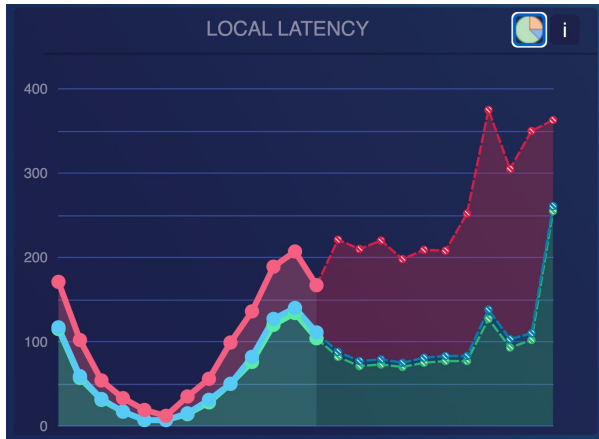
Coverage indicates whether the end-user has shortage in coverage or not. If a customer has coverage problems, ISPs can recommend they get a mesh system, update router, etc.



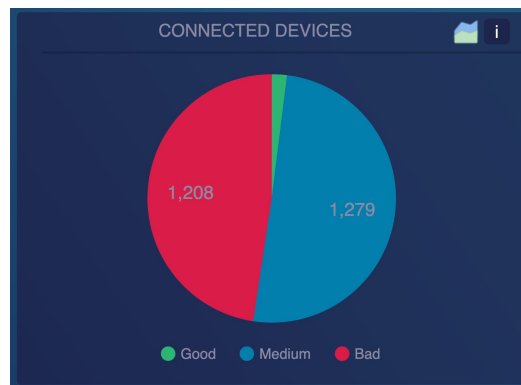
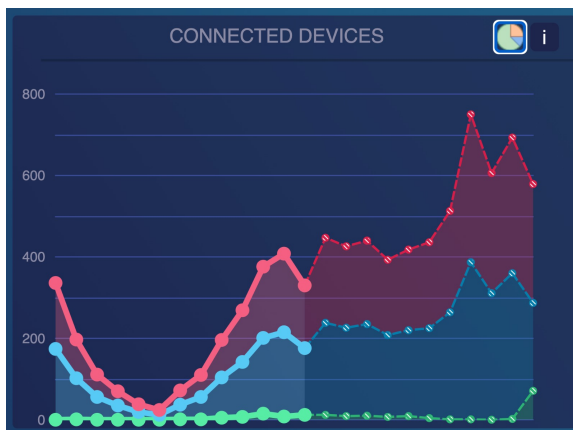
Wi-Fi Speed is the estimated throughput between the end-user device and the modem/router. When there is more than one person connecting to the same network, capacity may be downgraded. Information on Wi-Fi speed can help ISPs determine poorly performing devices on the network.



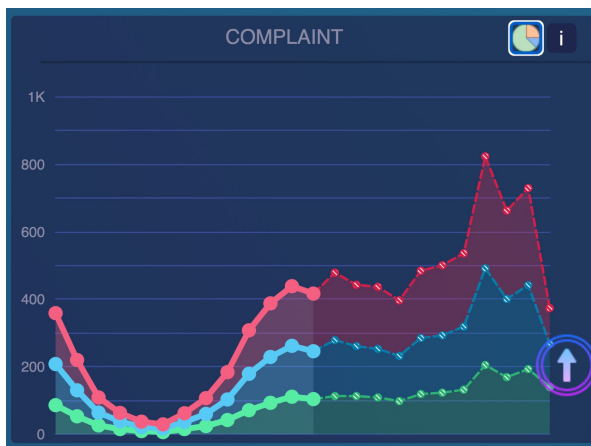
Local Latency represents the delay between the device and the router. This way you will be able to understand the density of usage in a given Local Area Network (LAN).



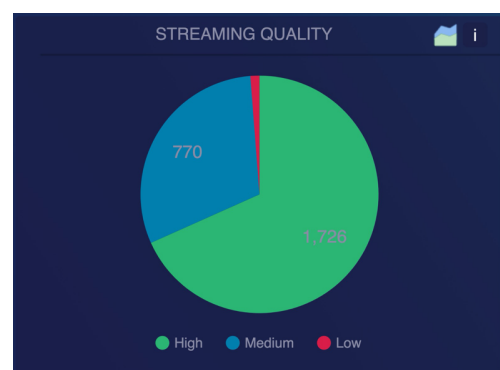
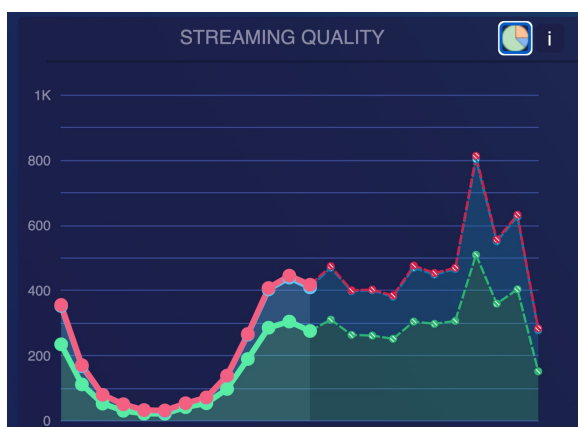
Number of Connected Devices indicates how many Wi-Fi devices are connected to the router at a given moment. It also provides a prediction of how many devices will connect in a given period time (hourly/weekly), peak hours, etc. which is useful to adjust network traffic according to demand.



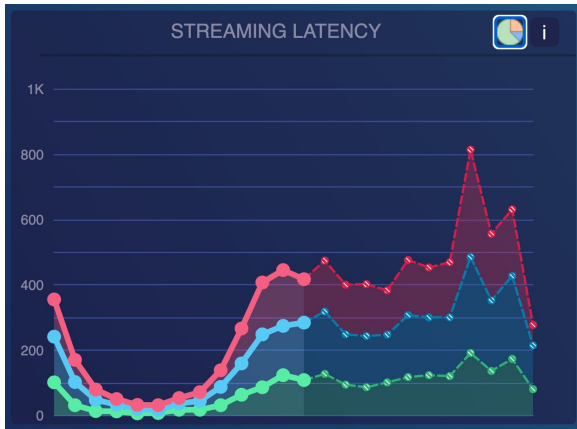
Customer complaints monitors customer complaints over time and predicts the number of customer complaints and complaints by specific subscribers. This can be used to create a smart ticket and solve incidents before subscribers are affected. This metric works together with synthetic network tests to be able to proactively understand an increase or decrease in customer complaints for specific groups of subscribers, subscribers based in specific locations, and at specific points in time.



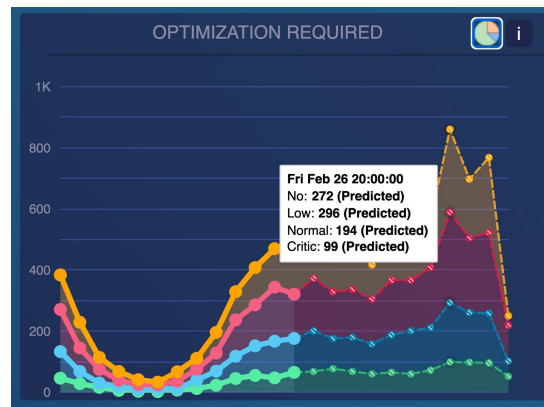
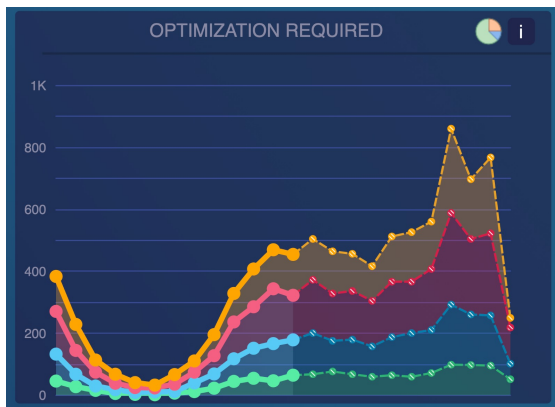
Streaming Quality dynamically measures network/infrastructure performance based on specific applications/traffic type (i.e. video, voice, data) used. A forecast is created, which can help ISPs adjust network data to route from different paths before end-users are affected.



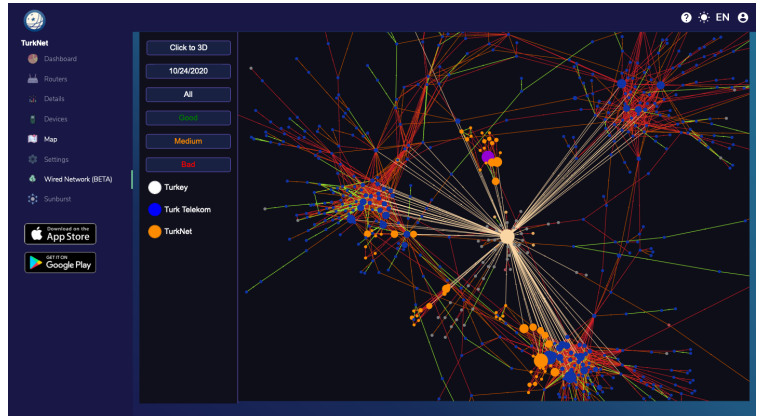
Streaming Latency dynamically measures end-to-end delay with regard to specific applications/traffic type (i.e. video, voice, data) used at any given moment.



Optimization Required measures and predicts how many access points will need optimization, and which channels need to be selected at any given moment of time. Ambeent provides the most optimal channel assignments powered by AI/ML. This will also help ISPs manipulate their traffic routing.



Problem Analysis of Wired Network (using ping tests) hop-by-hop metrics identify the domains in which issues occur, e.g. device level, ISP networks, SaaS application level, etc. Prediction is being implemented with Millenicom (ISP) where every hop point is scored over time and recommendations are provided to adjust traffic flow.

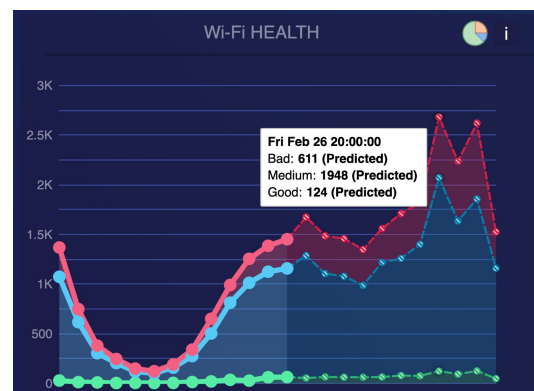
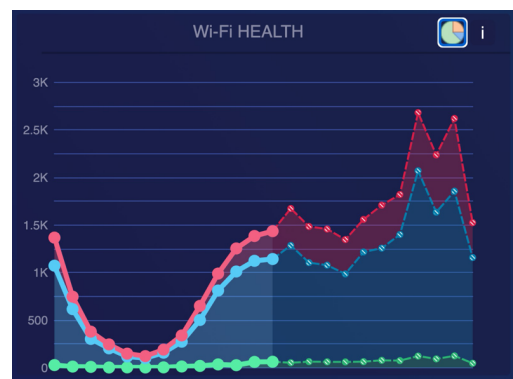
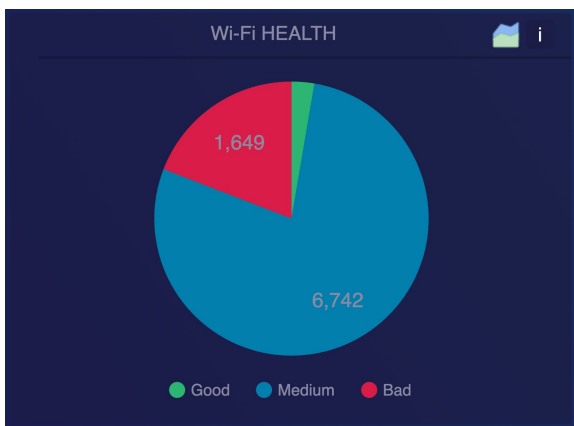


Router information (brand, model) shows the brand and models of routers deployed by end-users, and which ones show a tendency for weak performance. Historical data on router information can be used for detailed analysis of router behavior. It should be noted that Visibeel works with all router brands and hence, can collect extensive router information.

Device Information shows the operating systems in use by end-users and their versions. This information can be utilized to analyze specific application behaviors (upload/download characteristics) of end-devices. The type of operating system in use can also increase pressure on throughput. Hence, monitoring and prediction of operating systems used or will be used by subscribers can help ISPs plan better in case of updates.

Sunburst shows the level of link quality in different geographical locations (based on ping tests).

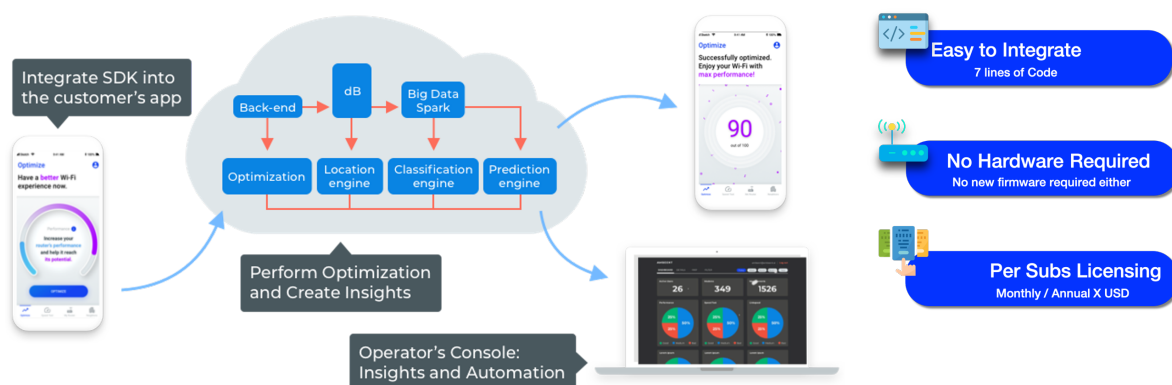
Wi-Fi Health is Ambeent’s unique formulation and combines multiple parameters, how well the router (AP) is placed, how much coverage capacity it has, the available data rate, how many devices were able to use the available bandwidth, etc (ML implemented).



Better identification of underserved households: Amid the pandemic, there are a variety of policy initiatives around the world to identify low-income families and neighbourhoods who are falling behind in terms of access. Ambeent tracks networks, wired and wireless, so that clients, including operators, can better pinpoint underserved customers / neighbourhoods and channel investments into these areas more intelligently. Operators can also offer more cost-effective service plans to low-income households⁶.

Intelligent infrastructure planning for broadband and 5G: Ambeent focuses on end user data, thus, its technology has the ability to collect and correlate data on usage patterns, existing broadband and cellular infrastructure in specific areas. This would allow investors to profile geographical conditions and predict network needs of specific locations. For instance, there may be less need for 5G infrastructure where broadband is already in place; or multiple 5G providers investing in the same region would have a better understanding of whether their investments are worthwhile. Optimizing infrastructure planning will also have positive environmental outcomes. This work would greatly complement the European Commission's projects on examining the mapping of broadband data on a European scale in the framework of its "Digital Single Market Strategy"⁷.

Platform Architecture: The Ambeent Console can be activated easily by user themselves, telco, universities, enterprise, and OTT customers. Once signed up, a group code is generated and used to link devices. This code is entered into the client apps in order to link the data coming from device to a specific console. A client can either download the Ambeent Wi-Fi Console App through an SDK on the device or through Google Play or Apple App Store. Browser-based plugins can also be deployed on desktops or laptops to monitor application performance of end-users in real-time.



⁶ During the pandemic, the UK's Office of Communications (Ofcom) secured commitments from major providers to conduct price reviews for their vulnerable customers.

https://www.ofcom.org.uk/__data/assets/pdf_file/0031/199075/bb-pricing-update-july-20.pdf

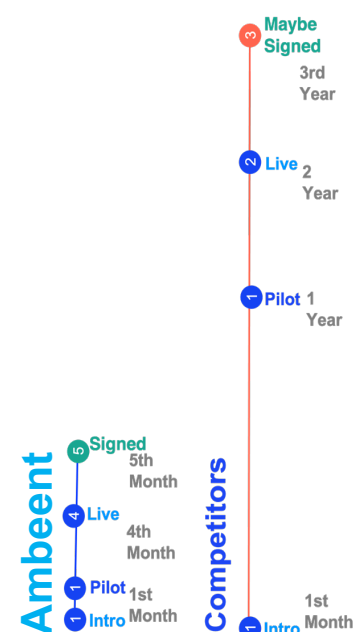
⁷ <https://ec.europa.eu/digital-single-market/en/broadband-and-infrastructure-mapping-project>

The Software Development Kit (SDK) is integrated into an existing mobile application. Various inputs are collected from the user node. Moreover, all the functionalities of the access point are transported to the cloud via user nodes. The Cloud platform runs an extensive AI engine to generate insights. It also performs spectrum optimization and dynamic channel allocation (for app-prioritizations). There are two outputs indicated in the figure above: One, the system achieves high performance Internet for users. Two, operators are provided with insights and automation to improve customer satisfaction and reduce technical assistance costs. Decentralizing the application on the device (mobile phone, laptop or IoT device) enables any operator or any other client to deploy the solution without delays and cost-effectively. The platform has:

- Capability to work with any CPE equipment
- Capability to work with any user device (iOS and Android compatible)
- Since there is no new hardware and firmware required, the price/performance ratio is profound.

Progress beyond the state of the art: Currently, there are various types of vendors that seek to address Wi-Fi problems resulting from channel interference on the unlicensed spectrum: providers of smart routers (TP-link, Huawei, Zyxel, Netgear, and Linksys), Wi-Fi Mesh Network Systems (Plume, Eero, Nest WiFi), **SD-WAN companies for enterprise WAN** (Cisco, Citrix, Riverbed, CloudGenix, VeloCloud, Viptela) and vendors providing tools for Network Performance Management and Diagnostics (NPMD) and Digital Experience Monitoring (Nyansa, Assia, 7Signal). Unlike Ambeent, these vendors take a restricted approach in tackling RF interference causing significant delays in data transfers: they do not take into account Wi-Fi interruption patterns and they do not carry out RF optimization in real time. Furthermore, all these solutions require new hardware and/or a software integration in the middleware gateway (i.e. access points) leading to complex and lengthy integration process.

Products	Plume	Assia	Airties	Nyansa	7Signal	Solar Winds	Accedian	Riverbed	Allied Telesis	AppNeta	Huawei Network Analyser	Sinefa	Thousand Eyes	Ambeent Platform
Scalability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
B2B Integration Time	✗	✗	✗	✗	✓	✓	✓	✓	✗	✗	✓	✓	✓	✓
User-centric	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Collaborative solution	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓
Accurate Wi-Fi speed	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Multi-Vendor solution	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wired / Wireless Networks	✓	✓	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓
Wi-Fi Offloading Assistance	✓	✓	✓	✗	✗	✓	✓	✓	✗	✗	✗	✗	✗	✓
Network Forecast	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ad-Hoc Wi-Fi Sharing	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✓
Digital Experience Monitoring	✓	✓	✗	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓



MAIN CHALLENGES FOR AMBEENT:

Business partnerships with large operators can take a long time to be realized. Operators are notorious for being very diligent about introducing a new technology, which translates into very long deployment cycles of typically eighteen to twenty-four months. This is a long time for a technology that evolves very quickly with ongoing innovations. The operator must invest quite some time performing integration, both at the gateway and central level, to ensure the new software runs smoothly and delivers on its promises.

A benefit to Ambeent's technology is having a decentralized function on the user device rather than the gateway. This means Ambeent's solution can be implemented with **zero integration**. The API is integrated into an existing application on a subscriber's mobile device enabling any operator to deploy the technology solution without delays.

Monitoring millions of devices of any kind/model, processing billions of measurements in real time. Ambeent continues to work on its AI algorithms to operate at large scale configurations, reaching millions of simultaneous active users in real time.

Expanding the Cloud library to include all modem models for Wi-Fi network monitoring. Ambeent has one of the largest modem libraries in the world to support its platform with zero integration. Ambeent targets to reach more than 90% of modem models and types all over the world.

Risk of others replicating Ambeent. Ambeent's technologies have a first-mover advantage in the field of virtualized network management, especially for in-home Wi-Fi networks, with more than 25 USPTO patent applications. Its AI/ML algorithms are increasingly competitive as its core optimization system has been collecting vast sums of data from mobile devices and Wi-Fi access points in the past years.

Increased concerns about data privacy /security and GDPR. Ambeent's system in fact makes routers more secure with its ability to detect hackers or any threat before users are affected. In terms of user data collected, Ambeent's B2C app strictly enforces the General Data Protection Regulation (GDPR) to ensure privacy and security. The technology also installs APIs in vendor mobile applications (e.g. those of consortium partners). These applications will be thoroughly examined for GDPR compliance before the system is deployed.

IMPACTS TO PEOPLE AND INDUSTRY

Ambeent will make Internet users happy, by ensuring fast and reliable Internet at affordable prices, especially in low-income areas. It will improve competitiveness of small business providing them with affordable digitalization. As significantly, Ambeent's solution, by cutting costs, will boost the revenues of presently stagnating telecom operators.

In sum, Ambeent's technology will have the following impacts:

- › Increasing connectivity of end users (including remote students and workers) by 99% through the implementation of Ambeent's API by broadband and mobile operators, as well as universities.
- › Increasing Average Revenue Per User (ARPU) of fixed and mobile broadband operators by decreasing their costs.
- › Elimination of customer dissatisfaction and resulting churn of broadband and mobile operators.
- › Better identification of underserved customers /neighborhoods by leveraging Ambeent's Console insights.
- › Improving efficiency of investments in the overall economy and the telecommunication industry with optimal 5G and broadband infrastructure planning.
- › Contributing to circular economy performance by reducing the number of unnecessary CPE replacements.
- › Increasing productivity of remote workers/students, SMEs.

CONCLUSION

Ambeent's solution comes at a historical moment where both the global telecommunications industry and enterprise networks are undergoing rapid change. The telco sector is in urgent need of agile, data driven solutions to address subscribers demands for simple and reliable digital experiences. Ambeent's network monitoring technology, offers analytics with automated workflows that can resolve any type of network problem even before users are impacted. On the enterprise side, Ambeent aligns business objectives with requirements for network visibility and agility. Its ability to work with existing hardware and software technologies and its very low-cost structure also makes it suitable for small to mid-size enterprises.

Above all, Ambeent addresses an urgent need during COVID-19 when digital technologies in general and in-home Wi-Fi networks specifically, are essential to our work and personal lives with more services and businesses moving online. At present, affordability and availability are two barriers that hinder access to the Internet for more than half of world population. Low-income families cannot afford monthly service fees (1GB can cost as much as 20% of the

average salary in some countries)⁸ and/or are saddled with dated internet equipment. Expensive fiber optic lines do not often reach poor areas. Though the digital divide mostly affects developing countries, there are deep digital gaps in high income countries as well.

Ambeent promises to make reliable, fast Internet more affordable. In an environment dominated by budget constraints, Ambeent offers operators an urgently needed, scalable, agile solution to achieve lower costs. In turn, operators can contribute to affordability of broadband services. Its technologies lessen the need for expensive Internet equipment by putting second hand, older APs into use. It ensures a high-quality internet experience in less developed areas where fiber is unavailable or expensive. Ambeent comes with the promise to unlock the digital potential for all users and enterprises of all sizes.

⁸ <https://a4ai.org/affordability-report/report/2019/>