Automated Wi-Fi Optimization differentiates your customers’ experience

For cable multiple system operators (MSOs), managing the Wi-Fi® customer experience in the home requires a comprehensive, analytics-based approach to Wi-Fi service assurance and customer care. By using home device and Wi-Fi analytics, MSOs can establish control over Wi-Fi performance, enabling both consumers and help desk agents to quickly, easily, and accurately assess Wi-Fi performance and optimize in-home Wi-Fi quality of service (QoS). When combined with self-organizing network (SON) technology, proactive analytics can be used to collect and analyze Wi-Fi device and network performance data, monitor the customer experience, predict and diagnose a poor quality of experience (QoE) and automatically correct device configuration problems. The resulting performance improvements translate into improved customer satisfaction, fewer calls to the help desk, a significant reduction in customer support costs and increased revenue from the introduction of new Wi-Fi-based services.
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Creating a reliable, quality Wi-Fi experience

Wi-Fi is becoming the most popular technology for the delivery of Internet services for residential consumers. In the modern home, at least six devices are typically accessing the internet using Wi-Fi technology. According to ABI Research, there were nearly 4.5 billion Wi-Fi-connected devices in use at the end of 2014\(^1\) and the total number of wireless access points (APs) shipped will surpass 204 million units by 2020.\(^2\) In addition to the sheer number of wireless APs, extra complexity is added by the fact that the devices do not come from a single vendor.

Unlike the hardware used to deliver cellular connectivity, wireless APs currently only operate on two frequency bands (2.4 GHz and 5 GHz; with 60 GHz for Gigabit Wi-Fi expected in the future), each of which has a limited number of available channels. Use of the 2.4 GHz spectrum has grown congested in recent years, with APs contending with wireless signals from microwaves, garage doors, baby monitors and a long list of other household devices. Some consumers are still connecting with APs that use older Wi-Fi technologies (e.g., 802.11b), which can also affect devices that use newer Wi-Fi technologies (e.g., 802.11n/ac).

The sheer number of wireless APs—sometimes referred to as “network densification”—is part of some communications service providers’ (CSPs’) strategy to provide uniform quality of service (QoS) across their network. Such complex and dense networks bring new business opportunities, but also result in practical challenges related to network optimization and management.

To address these problems, Nokia has applied a set of principles and concepts from the world of cellular data networks called the self-organizing network (SON). SON is an automation technology designed to make the planning, configuration, management, optimization and healing of mobile radio access networks (RANs) simpler and faster. Nokia has applied SON principles to Wi-Fi.

At first glance, the application of SON principles to Wi-Fi networks is not straightforward, owing to several significant differences between the two technologies. This paper does not attempt to examine all the technical complexities that must be considered when designing a Wi-Fi SON optimization process. Rather, this paper provides a summary of the patent-pending process developed by Nokia that is designed to improve the performance of wireless APs. The results include more stable Wi-Fi connections, higher average performance and fewer calls to the help desk.

A great deal of beneficial information can also be found in these existing white papers:

- Going mobile with branded Wi-Fi: a discussion of the importance of building quality into Wi-Fi connectivity, leveraging Wi-Fi assets for new revenues and ensuring a place in future value chains (http://resources.alcatel-lucent.com/asset/200373).
- Improving the in-home Wi-Fi customer experience for cable operators: an examination of consumer Wi-Fi and the importance of managing the customer experience in the home using a comprehensive, analytics-based approach to Wi-Fi service assurance and customer care (https://resources.nokia.com/asset/200554).
- Wi-Fi first: Should I do it? How do I do it?: a business rationale that examines various strategies that leverage Wi-Fi to provide ubiquitous connectivity for cable MSOs (http://resources.alcatel-lucent.com/asset/189270)

\(^1\) http://www.wi-fi.org/news-events/newsroom/total-wi-fi-device-shipments-to-surpass-ten-billion-this-month

\(^2\) http://www.telecompetitor.com/wi-fi-802-11ac-shipments-now-65-of-all-wi-fi-access-points/
• Multiple System Operator (MSO) Wi-Fi: Solutions to enhance the connected lifestyle; an exploration of some of the market trends (https://resources.alcatel-lucent.com/theStore/files/Nokia_MSO_Wi-Fi_Solution_Marketing_White_Paper_EN.pdf)


This document summarizes some of the challenges associated with deploying Wi-Fi technology for residential applications, provides a high-level view of how SON can help to mitigate these challenges, then outlines some of the business benefits of deploying an end-to-end customer care solution that includes Wi-Fi SON optimization technology. The improvements resulting from the technology outlined in this white paper can result in savings of more than $1.5 million per year for each 500,000 MSO subscribers using wireless APs.3

What are the common causes of Wi-Fi-related issues for consumers?

As the home networking environment becomes more complex, it is increasingly harder for MSOs to get a clear view of the state of the home Wi-Fi network or how the equipment or environment may have changed since initial deployment. Most wireless APs are designed to automatically select the optimal operating channel, based on its individual requirements. There is no consideration for the performance of other, nearby APs which might be impacted. In addition, each time an AP is turned on or rebooted, the channel that it uses can change.

In a typical urban location, there can be dozens of Wi-Fi networks visible at any time. Many consumers don’t know if a nearby AP is configured on an overlapping wireless channel and—even if they are aware—most are unable to diagnose and solve these common issues alone. Overlapping wireless channels typically result in interference that can cause delays in data transmissions, reduce throughput and cause drops.

For most consumers, congestion and co-channel interference may not be noticed because it doesn’t impact the use of e-mail or most social media applications. Problems become more pronounced during the consumption of real-time services, like streaming audio, video and voice calls.

Current approaches to Wi-Fi optimization—like automatic channel change—have limited effect because they work with individual APs, without consideration for neighboring APs. In multi-vendor deployments, with a large installed base, proprietary solutions from wireless AP vendors are not practical.

The cost to support Wi-Fi is soaring

Many initial cable MSO Wi-Fi projects have been conceived as defensive plays, intended to be a differentiator to increase loyalty and keep customers on the network. However, Wi-Fi connectivity is now considered table stakes for CSPs of all kinds. Without a technical solution like Wi-Fi SON, the cost to support Wi-Fi will continue to soar.

Wi-Fi-related issues are the number one technical support call driver for most global CSPs, driving more than one-third of calls to their help desks. Wi-Fi is also a major source of customer dissatisfaction. Top Wi-Fi-related issues include problems with passwords, device setup, disconnects, and of course, overall performance. In fact, 70 percent of subscribers perceive that they have problems when streaming or downloading over Wi-Fi.4

3 Based on Nokia internal estimates.
4 Going mobile with branded Wi-Fi, Nokia, 2016; (http://resources.alcatel-lucent.com/asset/200373
Densely populated neighborhoods and multiple dwelling units (MDUs) exponentially increase the number of wireless APs, threatening to make Wi-Fi service unusable. One solution could be to move to the 5 GHz spectrum, though not all devices support 5 GHz. Eventually, like the 2.4 GHz spectrum, saturation problems would emerge in that frequency band as well.

For MSOs considering a move towards becoming a Mobile Virtual Network Operator (MVNO), the residential Wi-Fi network will become a required component in offering Voice over Wi-Fi (VoWi-Fi) and Wi-Fi Calling services. MSOs need to understand and control the home Wi-Fi experience. Currently, however, many MSOs are blind to in-home issues without a technician on-site. A more effective solution is a proactive remote Wi-Fi optimization approach.

**Wi-Fi First and Wi-Fi Calling are key for most MSOs’ strategies**

Wi-Fi First refers to mobile devices and services that use Wi-Fi as the primary network and cellular networks only to fill the gaps. For MSOs that are also MVNOs, deploying a Wi-Fi First strategy implies an increased focus on capabilities to manage voice and connectivity between Wi-Fi and cellular. Savings can be achieved by steering voice calls to Wi-Fi while in the home as approximately 65 percent of end-user calls made over the MSO network will be home-based. Wi-Fi First and Wi-Fi Calling make the need for optimized use of the Wi-Fi spectrum even more important, as customers are less forgiving when they have problems making voice calls. By moving aggressively to expand their Wi-Fi presence with all the new tools at their disposal, cable MSOs will be able to enhance the consumer experience and the monetization potential of their wireless connections.

**Optimizing the performance of Wi-Fi networks**

Wireless access points (APs) operating according to the IEEE 802.11 Wi-Fi standard can utilize a selection of channels, each characterized by a certain frequency spectrum. When an AP is initially powered on, it automatically selects the channel with the least interference, from a subset of non-overlapping channels. This automatic channel selection feature is typically programmed to select channel 1, 6 or 11, but it can also be disabled. Because channel selection is based on the AP’s individual requirements, there is no consideration for the performance of other, nearby APs which might be impacted.

As a result, if neighboring APs operate in the same frequency spectrum (which is nearly impossible to avoid), overlapping is likely to occur. This causes interference that can result in a performance decrease. In an ideal scenario, each individual AP should utilize a channel that provides the best throughput possible, while attempting to minimize the interference it might cause to neighboring APs. Nokia has developed a patent-pending technique for assigning optimal channels to APs.
Doing the scan

Before channels can be re-assigned to the various APs in a multiple-AP environment, each AP must perform a scan. This scan is initiated using a device management platform and is enabled by the AP’s ability to support both the TR-069 and TR-181 (version 2.7 and above) standards, as defined by the Broadband Forum. (The specific commands available are “Device.WiFi.NeighboringWiFiDiagnostic” and “Device.WiFi.NeighboringWiFiDiagnostic.Result(i)”.) The purpose of the scan is to provide some baseline information, such as:

- a list of all “neighbor” APs, those that are within range where interference is possible
- the frequency channels that are currently used by the neighbor APs
- which APs are manageable and which are unmanageable; unmanageable APs are either owned by another CSP or otherwise unavailable for modification
- the amount of path loss experienced by each AP

The results of the various scans are used as a starting point for the performance optimization process. Figure 1 illustrates an environment with both manageable and unmanageable wireless APs. The green APs (denoted as AP2, AP3, AP5 and AP6) are all manageable because they are connected to the common platform. This means that the CSP can change the settings of these APs. The red APs (denoted as AP1 and AP4) are not connected to the platform, making them unmanageable. This means that their settings cannot be modified by the CSP.

The two-headed black arrows in Figure 1 represent each AP’s ability to see (and be seen) by another AP. It is important to note that, although AP1 and AP4 are not connected to the platform and, thus, cannot be managed, their presence must be considered as they can still impact the performance of the other four APs.

![Figure 1. A visual representation of six wireless access points](image)

Each of the APs shown in Figure 1 are operating on a channel that is selected by the AP itself. This might be the ideal channel for that AP, but it does not take into consideration the performance of the neighbor APs, which might be impacted by overlapping spectrum.
Grouping the access points into ‘cliques’

Based on the path loss calculated by the various scans, APs are automatically grouped into subsets, called ‘cliques’. This subdivision leads to a global optimization of the channel allocation process. Owing to the constantly-changing nature of technology, and with APs being added (and removed) on a regular basis, it is likely that the channel allocation process will be continuous.

Figure 2 illustrates the first clique of APs that has been established (Clique #1), made up of four access points (i.e., AP3, AP4, AP5 and AP6).

Prior to assigning channels to an AP, all applicable limitations need to be considered. For Clique #1, there are several limitations that need to be considered:

- AP4 is unmanageable, so the channel assigned to AP4 is not available for any of the other three APs in the clique
- AP3 is a member of another clique (Clique #2, as shown in Figure 3) and has five neighbors (including AP1, which is not manageable, imposing one more limitation to AP3)
- Because AP3 has multiple limitations, it is the most difficult to configure and should be the first AP to have a channel assigned. Any channel is available to AP3, except for the channels already assigned to AP4 and AP1.

The next two APs (AP5 and AP6) both have three connections and belong to just one clique (Clique #1). As a result, channels should be assigned to AP5 and AP6 next; in any order. Any channel is available to AP5 and AP6, except for the channels already assigned to AP3 and AP4. If AP5 is assigned a channel first, AP6 will be the last AP to have a channel assigned in Clique #1. After the process is complete, AP6 is the most likely to suffer from some interference issues because it was the last AP to be configured. All of the “good frequency” might have already been assigned to the other three APs.

Figure 3 illustrates the second clique of APs that has been established (Clique #2), made up of three access points (i.e., AP1, AP2 and AP3).
For Clique #2, there are several limitations that need to be considered:

- AP1 is unmanageable, so the channel assigned to AP1 is not available for any of the other three in the clique.
- AP3 is a member of another clique (Clique #1, as shown in Figure 2) and has already been assigned a channel.

In fact, this makes the process simpler, as only AP2 needs to have a channel assigned. Any channel is available to AP2, except for the channels already assigned to AP1 and AP3.

**Channel allocation is only part of the customer care process**

The process described in the previous section is intended to minimize the interference caused by overlapping Wi-Fi signals, resulting in the optimal performance of wireless APs. However, this automated process cannot be viewed in isolation. It must be part of a comprehensive, end-to-end customer care solution.

For many consumers, the customer care process begins either with a call to the help desk or with a CSP-provided self-service application (app) on their smartphone or tablet. It is for this reason that the steps involved in the automatic Wi-Fi channel allocation process need to be made visible to CSRs, business analysts and other personnel involved in the customer care process. If the optimization process is a “black box”, it becomes difficult to assess its impact on the overall customer care process and eventually the customer experience. This is especially true for in-home Wi-Fi networks that are typically characterized by a variety of multi-vendor devices, using unlicensed wireless spectrum that, as discussed earlier, is prone to interference from neighboring networks and non-Wi-Fi devices. Furthermore, these environments are always changing; with new firmware versions, new consumer devices (e.g., Internet of Things, or IoT), new services and new technologies.
Although Wi-Fi SON solutions must adapt to changing conditions quickly and effectively—with as little human involvement as possible—the SON solution must consider recent previous actions completed by the CSR, by the subscriber (using a self-care app), or by a field technician. In other words, the SON solution must ensure that it doesn't take actions that have already proven to be unsuccessful.

On the other hand, the CSR must avoid performing actions that have already been attempted by the SON solution as this might conflict with, or hamper, the effectiveness of the SON solution (e.g., if a CSR decides to assign a specific channel to an AP, over-riding the automated optimization process). To do this, the CSR must have visibility on the actions taken by the SON solution and the SON solution must have visibility on the actions taken by the CSR, subscriber or field technician.

The intricate interplay between the agent-assisted care, self-care, field technician involvement and the Wi-Fi SON proactive care process requires careful coordination. For example, the automatic allocation of Wi-Fi channels cannot be done at any time of the day. Changing the channel of the wireless AP will take users offline and will cause a brief service disruption. For this reason, the automated process must be programmed to run the scan, then wait to make any channel changes until there is either no traffic being processed by the AP (e.g., in middle of the night or during a scheduled maintenance window). At the same time, if the scan determines that significant interference is likely to cause a service disruption for a subscriber, that information should be made available to a CSR, along with detailed information for correcting the issue. Alternatively, a step can be added to proactively notify the customer (e.g., via an e-mail or through app), with the appropriate details and preferred steps that they should take.

To maximize the effectiveness of the process, there will be a need for new SON use cases to be designed and deployed on a regular basis. Business analysts should perform these use cases, not CSRs, based on the insights and reporting tools provided.

By having a care analytics platform in place that can track actions and their success or failure across all care channels, the evolution to proactive care can be accelerated whenever new services are introduced (e.g., VoWi-Fi) or existing services are evolving (e.g., offering Wi-Fi extenders to assist with the deployment of set-top-boxes (STBs) anywhere in the house for IPTV). It is the analytics platform that provides the necessary insights for the business analysts to design or tweak the care processes, as well as highlight which anomaly patterns in the customer care and customer premises equipment (CPE) data could benefit from an automatic repair action.

**Business case: Optimal Wi-Fi performance leads to significant cost savings**

A company with 500,000 subscribers using wireless APs in the field can expect to get approximately 17,500 calls per month. It usually takes 26 minutes to resolve a Wi-Fi-related help desk call. At an average cost of $0.70 per minute, this translates to $18.20 per call, or $318,500 per month. Factor in a small number of field technician deployments (10% of the total number of monthly help desk calls received—1,750 in this case—would be typical), at an average cost of $80 per truck roll, and you get another $140,000 per month in support costs. On an annual basis, the combined costs total a little more than $5.5 million per year.\(^5\)

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\(^5\) Based on Nokia internal estimates
Based on these estimates, the cost savings that can be realized with a powerful customer care solution are significant. Reducing the number of help desk calls by just 10% (from 17,500/month to 15,750/month), for example, will result in a savings of $29,850 per month ($358,200 per year). Reducing the average handle time (AHT) by 25 percent (from 26 minutes to 19.5 minutes), would result in monthly savings of nearly $80,000 per month (nearly $1 million per year). Finally, reducing the number of field technician deployments by 12.5 percent (from 1,750 per month to 1,530 per month), will save an estimated $17,500 per month ($210,000 per year). Realizing all three of these efficiencies at once would result in savings of $127,350 per month or more than $1.5 million per year.6

Other benefits include performance improvements for consumers. Typically, optimizing the performance of wireless APs results in a vast improvement (more than 100%) in the Signal to Noise + Interference Ratio (SNIR), resulting in a 45 percent improvement in the download speed experienced by consumers and a 22 percent improvement in their upload speed.7

Delivering an enhanced customer experience with optimized Wi-Fi

Nokia is the leading provider of omni-channel customer care solutions for home, mobile, small cell and enterprise devices and services. We help companies adopt care processes that deliver the highest possible customer satisfaction at the lowest possible cost. Our Nokia Customer Experience Solutions (CXS) are the choice of hundreds of companies seeking to give CSRs, technicians and customers solutions that help drive loyalty and generate short-term return on investment (ROI).

The products included in the provision of Wi-Fi optimization services, as outlined in this paper, include:

- **Nokia Connective Device Platform (CDP)** provides a highly scalable device management framework to remotely control and manage multi-vendor CPE, including a variety of wireless APs. Nokia CDP also provides full support for IPv6 devices and industry standards like TR-069, simple network management protocol (SNMP) and TR-181.

- **Nokia Service Management Platform (SMP)** offers the ability to fully define and normalize key service and device configuration settings as well as management actions. Using workflows, MSOs can maximize existing investments in device management, business and operations support systems (B/OSSs) and extend service management visibility and control across the entire service delivery ecosystem.

- **Nokia Care and Support Applications** simplify your assisted care, self-care, and field support operations. Combining service orchestration with service intelligence, these applications let you increase first-time fix rates and deliver effortless customer experiences across all channels.

- **Nokia portfolio of CXS Analytics Solutions** provide data collection from managed devices, access networks and customer care workflows. Nokia **Home Analytics (HAL)** provides recommendations and proactive actions to correct the in-home Wi-Fi experience, including coverage recommendations, where extenders might be deployed and more. The optimization of Wi-Fi should not be limited to interference; improving coverage is also part of a comprehensive approach to customer care.

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6 Based on Nokia internal estimates
7 Based on lab tests performed by Nokia
Summary

Subscribers using wireless APs for their high-speed Internet service expect to have optimal network performance at all times, from any location using any device. However, the proliferation of connected devices—and the inherent limitations of existing technologies—are resulting in decreased Wi-Fi performance, reduced customer satisfaction and an increase in operational expenses.

By applying the principles of SON technology to Wi-Fi, Nokia makes the planning, configuration, management, optimization and healing of wireless APs simpler and faster. The resulting performance improvements translate into improved customer satisfaction, fewer calls to the help desk, a significant reduction in customer support costs and increased revenue from the introduction of new Wi-Fi-based services.