Aerohive NETWORKS

white paper

Service Level Assurance

Wireless Fidelity Achieved

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Introduction

Networks are living creatures, ever-growing, ever-changing, and Wi-Fi networks change even more quickly and in more ways than wired networks. New APs are deployed, neighboring networks pop up, clients roam, data rates change, and flash crowds converge on one part of the network. Users love the freedom and mobility, but they also demand that IT consistently deliver predictable performance in spite of the dynamic nature of the network. Wi-Fi networks are getting faster and smarter, and that helps, but Wi-Fi administrators are still hampered by having minimal visibility into how well they are actually delivering what their users expect. Administrators don't typically have visibility into the performance level being provided to the Wi-Fi clients by the infrastructure, and their infrastructure only has limited ability to dynamically adjust to deliver the experience their users are demanding. Today's Wi-Fi administrators can only hope their clients are getting the planned level of performance - and that isn't good enough.

Before Wi-Fi protocol analyzers, administrators and consultants alike were only able to troubleshoot by continually reviewing the network design of and device operation within the network infrastructure. Gathering meaningful performance statistics and performing trouble analysis and repair was difficult, if not impossible. With the introduction of Wi-Fi protocol analyzers, these professionals had the equivalent of RF goggles. They could now see what was happening and could reactively troubleshoot problems. The problem with this approach is a lack of ability to properly diagnose and repair performance problems in near real-time. With this in mind, Aerohive has introduced the next level in network visibility and automatic reactive response. Aerohive's new infrastructure-side performance monitoring and response system, dubbed Service Level Assurance (SLA), increases the troubleshooting granularity and active response speed far beyond what any IT professional could accomplish manually and paves the way for IT to move towards actual performance guarantees.

Wi-Fi That Works

Some call it Wi-Fi Utility. Others call it network determinism. We call it Wi-Fi that works. The IEEE's plan for the 802.11 standard has always been to implement inter-AP protocols to do the work of client handoffs, spectrum management, and much more. Aerohive aligned its thinking and methodology with that of the IEEE, building its own high-performance Cooperative Control protocols between its HiveAPs. Then the Wi-Fi Alliance began with an advertising slogan of, "The Standard for Wireless Fidelity." Again Aerohive has answered that call, implementing real Wireless Fidelity, when defined means: adherence, reliability, integrity, precision, and surety.

We believe that there should be some baseline of performance that you can count on – or even better – guarantee. Every network technology has to start somewhere and then progress forward. First, Ethernet was established in data centers, and then in distribution and access layers. Next a variety of Internet access technologies such as dial-up and ADSL were introduced. Now it's Wi-Fi's turn. We take most of these connectivity technologies for granted, and Wi-Fi should be no different. There are several parameters that factor into utilitarian networking. Let's take a look at some of those factors.

A Simple Machine

Does it work every time you need it? If you haven't tinkered with it in a while, will it still give you unwavering dependability? Unfortunately, the answer is often no. So, the

challenge is to build the equivalent of a networking simple machine. We know that a lever, a pulley, or an inclined plane is going to function every time. It's in their nature. That's what we need here as well, only we're dealing with over 2,600 pages of the IEEE 802.11 standard (with amendments), so that's no simple undertaking. The concepts we're talking about are reliability, availability, and predictability.

The first rule of building a reliable system is to remove all unnecessary parts, and that is where simple machines get their names. One relevant example of minimization: replacing a Wi-Fi controller with inter-AP protocols. Protocols are either on or off (refer to Figure 1). They don't experience wear and tear, they don't use any power, they don't require licensing or warranties, and they don't take up space in a landfill when they die…and make no mistake, controllers do die.

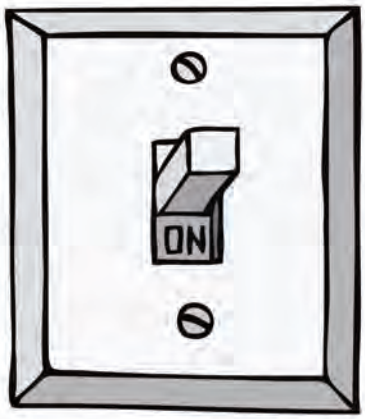

Figure 1: Utilities Offer Two Options: On / Off

When your network is life critical, learn critical, or livelihood critical, nothing less than just works will do. Words like partially, mostly, and sort of just won't cut it.

Industry Response To-Date

Vanilla 802.11 is a distributed free-for-all, devoid of certainty, and where Wi-Fi is used only as a network of convenience, performance is often near the bottom of the priority list. Due to Wi-Fi's transition to mission-critical status in the enterprise, vendors have been incrementally delivering features that offer measures of improved performance. These features generally fall into two categories: prioritization and optimization. You may have heard of some of them: WMM QoS, Bandwidth Management, and Airtime Fairness. Some of these features are better than others, and all of them are a step in the right direction, but they are simply pieces of a larger puzzle.

Today's leading enterprise-class Wi-Fi solutions attempt to optimize client performance and to deliver predictable behavior. However, they are unable to effectively report on whether they were successful in delivering this performance and have no automated response mechanism for when they are unsuccessful. This is where Aerohive has innovated.

Service Level Assurance – An Introduction

Aerohive's new Service Level Assurance (SLA) with Performance Sentinel and Airtime Boost features and Client Health Score integration provides network administrators unprecedented levels of Wi-Fi visibility and determinism by monitoring every client's -

- Capabilities (e.g. 802.11a/b/g/n)
- Real-time throughput
- Airtime use/abuse
- Client Health Score (e.g. Retransmissions/Drops, Signal Strength, WLAN & non-WLAN RF Interference levels, client behavior, etc.)

- against its predefined SLA and reporting this information to a single, widgetized dashboard.

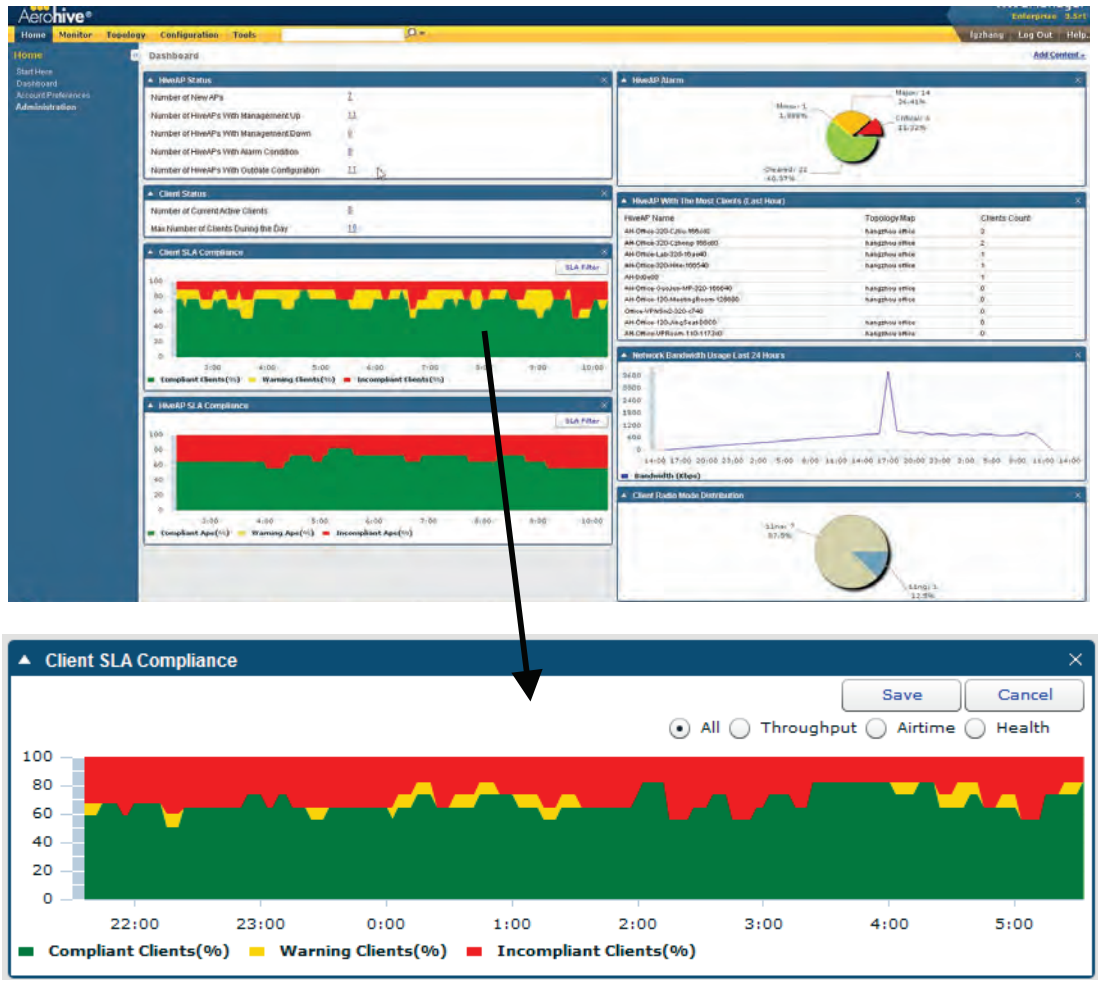

Figure 2: A Widgetized Dashboard for Complete Visibility

This gives early visibility into coverage or capacity issues, and appropriate corrective actions are automatically taken with each client that is not meeting its SLA and/or that doesn't meet a Client Health Score threshold. For example:

- Additional airtime can be automatically allocated to clients
- Clients can be load-balanced to another AP on the same band
- Clients can be band-steered to another radio on the same AP

Service Level Assurance (with Performance Sentinel and Airtime Boost) and Client Health Score features are each a first in the Wi-Fi industry.

A Holistic Approach

Real wireless fidelity requires a holistic approach to SLAs. Figure 3 illustrates the industry's step-by-step progression toward SLA monitoring and actions. A holistic approach must include the ability to ensure throughput and wireless link health requirements are achieved through:

- SLA & Client Health definition & monitoring
  - Enables the administrator to specify a minimum throughput and client health score thresholds
- Problem analysis
  - Isolates problems down to the client or AP when there is a violation
- SLA actions
  - Dynamic client movement or resource allocation to recover from violations

SLA visibility, fault-recovery actions, and in-depth analysis will allow the network administrator to see the big picture while the Wi-Fi platform does all of the work.

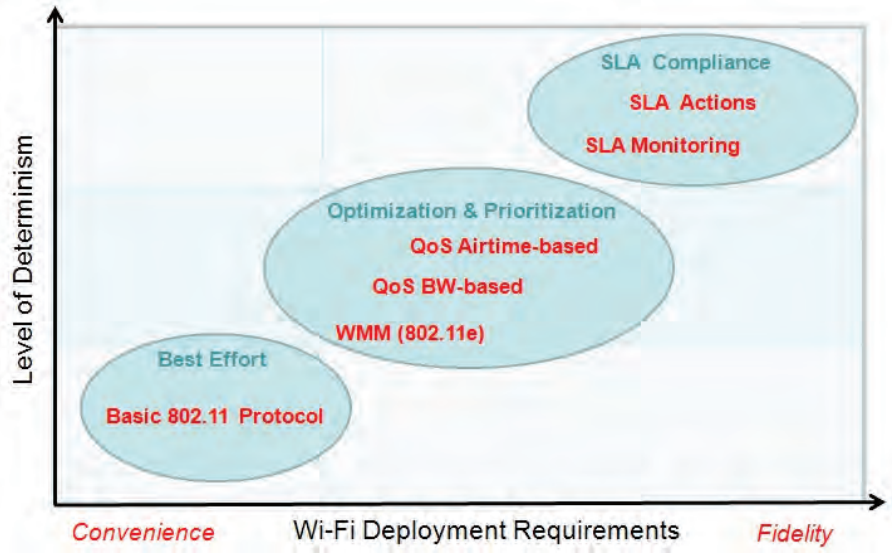

Figure 3: The Progression from Convenience to Fidelity

What does Ms. Smith, the payroll clerk, care about WMM traffic prioritization or airtime scheduling? She doesn't. She, like all other Wi-Fi users, wants to know that her network connection will give her what she's supposed to have wherever and whenever she goes. She wants a guarantee. It's just that simple.

Ms. Jones, the network administrator, wants something too, but her perspective is different. Ms. Jones wants Ms. Smith to get the expected network behavior, and if that doesn't happen, she wants to know when, why, what action was taken, and whether or not the action repaired the problem. Before this can happen, SLAs must be defined, monitored, and enforced.

SLA Compliance – How It Works

Aerohive delivers another industry first, introducing a new realm of determinism and network visibility. These features enable IT, for the first time, to establish, monitor, and deliver throughput guarantees for Wi-Fi clients while monitoring client health individually and collectively using numerical scores that fall within stop-light (green, yellow, red) categories.

Performance Sentinel

In order to monitor the network, Aerohive has introduced Performance Sentinel – a client throughput service level monitoring engine. Performance Sentinel characterizes whole-network performance, from a throughput perspective, and reports on achievement from a single dashboard (e.g. 98% of our clients achieved 3 Mbps throughput or greater for the last 3 months). In Figure 4, HiveManager's SLA reporting shows that 3 clients on a single AP were in violation of the SLA (Red). When Airtime Boost (discussed in the next section) is enabled, reporting shows all clients and APs are SLA-compliant, 3 clients being compliant as a result of the Airtime Boost action (Yellow).

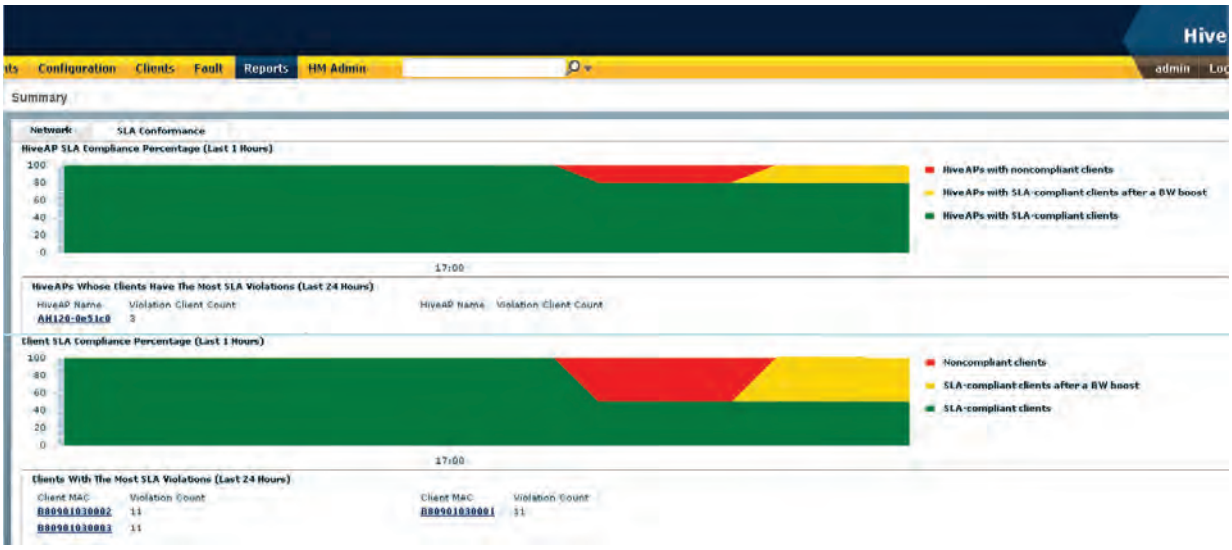

Figure 4: Network Visibility (APs & Clients) – The Dashboard

Performance Sentinel compares client throughput and demand with a predefined throughput SLA level by:

- Using client data statistics to determine client throughput
- Using buffer statistics in the QoS engine to determine if a client is actually trying to download more data

In addition to client-side visibility, APs can also be monitored to pinpoint which had clients with SLA violations, which could be the result of interference or capacity problems.

Airtime Boost

In order to provide automatic recovery action for stations not meeting their SLA, Aerohive has introduced Airtime Boost – a feature built on Aerohive's innovative Dynamic Airtime Scheduling engine that automatically allocates additional airtime to lagging stations.

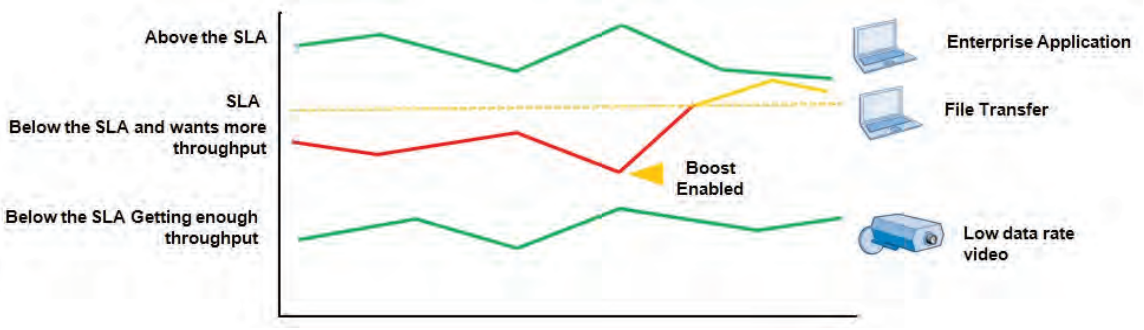

Figure 5: Airtime Boost Functionality

Aerohive's Dynamic Airtime Scheduling feature allows fast clients to achieve high throughput and slow clients to achieve their normal level of throughput without unfairly penalizing either client type. Applying Airtime Boost technology to user profiles allows IT to pre-configure the system to assist particular stations in achieving their SLA when a problem is noted by Performance Sentinel.

Now IT can create different classes of clients (user profiles), give them different SLA levels, and have the system automatically respond if they are not being met. Some examples:

- Medical imaging clients need 6 Mbps throughput to work properly
- Administration clients work fine with 3 Mbps throughput
- Guest clients could be set at 1 Mbps and only logging non-compliance

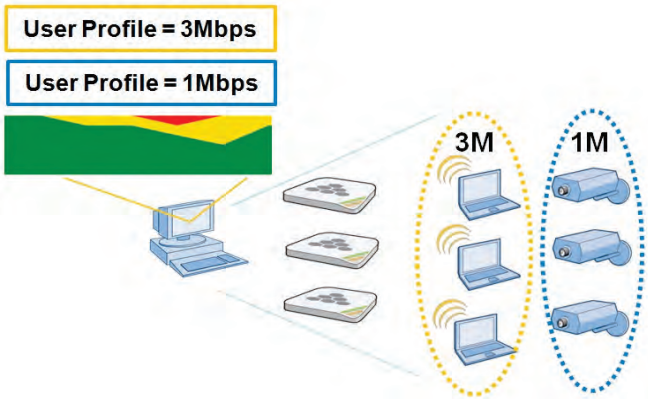

Figure 5: Airtime Boost: Building on Dynamic Airtime Scheduling

Client Health Score

The iEverything Wi-Fi client explosion has been expensive and difficult to manage, and the majority of IT professionals are not RF experts. IT departments need greater visibility into and control of their users' Wi-Fi experience. They need a complete picture of how Wi-Fi clients are performing versus their deployment goals, the ability to automatically or quickly resolve

connectivity issues, and the ability to deliver greater user satisfaction, improved productivity, and reduced operational cost.

Most Wi-Fi systems offer administrators an overwhelming amount of statistical data, but do nothing to present the data in a format efficiently digestible by the average wireless administrator. By rolling all of those statistics into a preconfigured-yet-customizable green/yellow/red format, administrators save a significant amount of time figuring out whether a client's connection is good, marginal, or poor. Sure, the statistical data is still available with a simple click, but would you prefer to dig through that data for each client manually or have the management system do it for you in real-time?

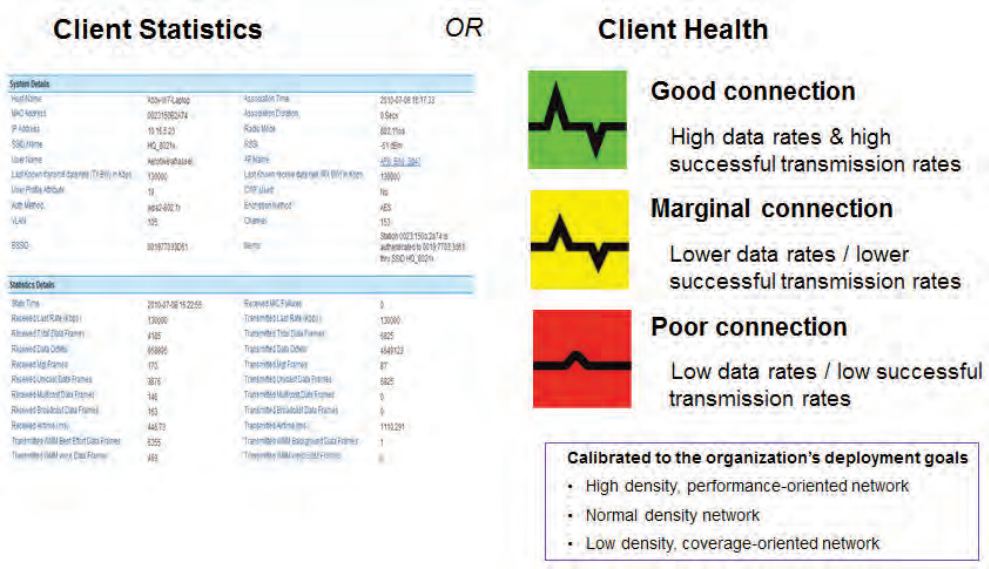

Figure 7: Client Health Score Concept

Client Health Scores are based on a variety of statistics, and administrators can easily customize the definitions of good, marginal, and poor, which are normalized against the type of client, its capabilities, and the deployment goals for the organization. Perhaps you are operating a high-density, performance-oriented network such as a conference center, school, or a stadium. Without detailed RF statistical knowledge, you can calibrate your system for that environment.

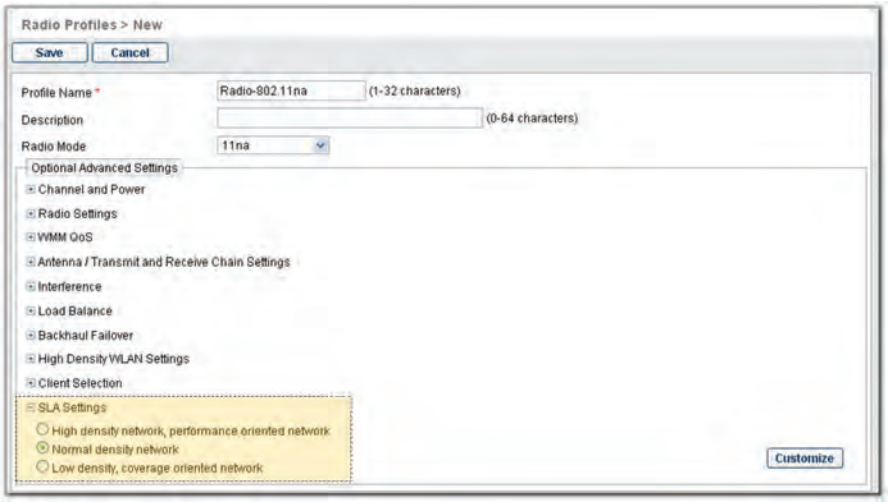

Figure 8: Client Health Score Calibration

The same is true if you're operating a low-density, coverage-oriented network such as a warehouse, hotel, or campground or just a normal-density network such as an office or hospital. Just a single click, and your system is calibrated for your deployment goals.

"Normal" is relative to multiple factors in a Wi-Fi network. For example, an 11 Mbps data rate is good for an 802.11b client, only marginal for an 802.11g client, and quite poor for an 802.11n client. By monitoring successful transmissions, data rate capabilities, actual data transmission rates, CRCs, retries, drops, and other parameters, HiveAPs understand, and will report, on the health of each client's wireless link with the AP. Figure 9 illustrates the concept of how "normal" is determined.

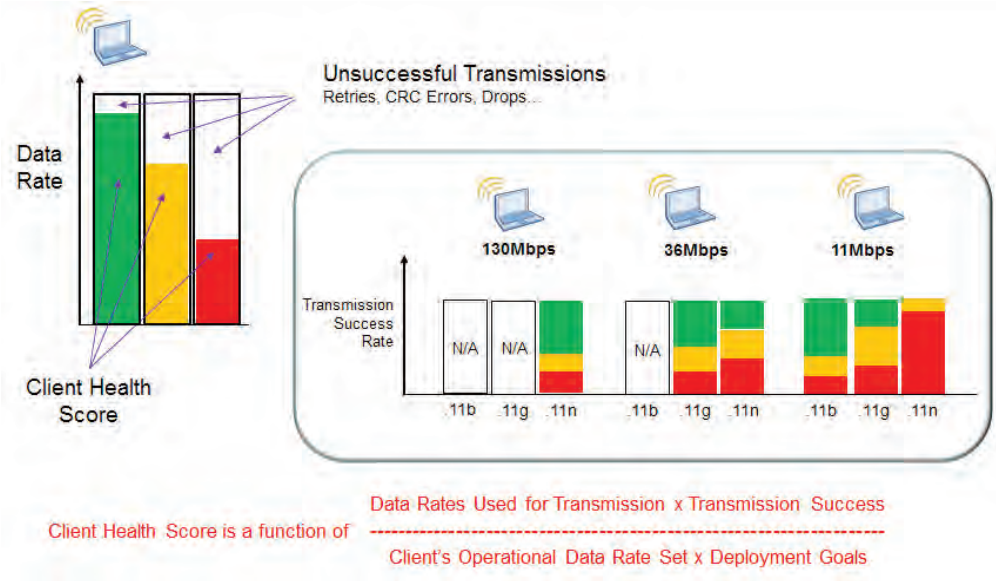

Figure 9: Client Health Score Details

By monitoring client types, capabilities, behavior, and connection statistics in real-time and applying appropriate and automatic corrective action, Aerohive has introduced the first Wi-Fi infrastructure with artificial intelligence. Do you read me, HAL?

The Drill-Down

IT administrators now have a dramatically-simplified client analysis engine that:

- Illustrates client problems in an easy-to-understand green/yellow/red format.
- Isolates problems to the client or AP when there is an SLA or Client Health problem, before the user has had time to complain.

Client Health Score integration into Aerohive's SLA feature provides at-a-glance health data and a simple drill-down, via a single click, to a rich set of statistical information on the client or AP, including: identity, data sent/received, data rates, RSSI values, performance, errors, retransmissions, drops, interference, load, airtime usage, and much more.

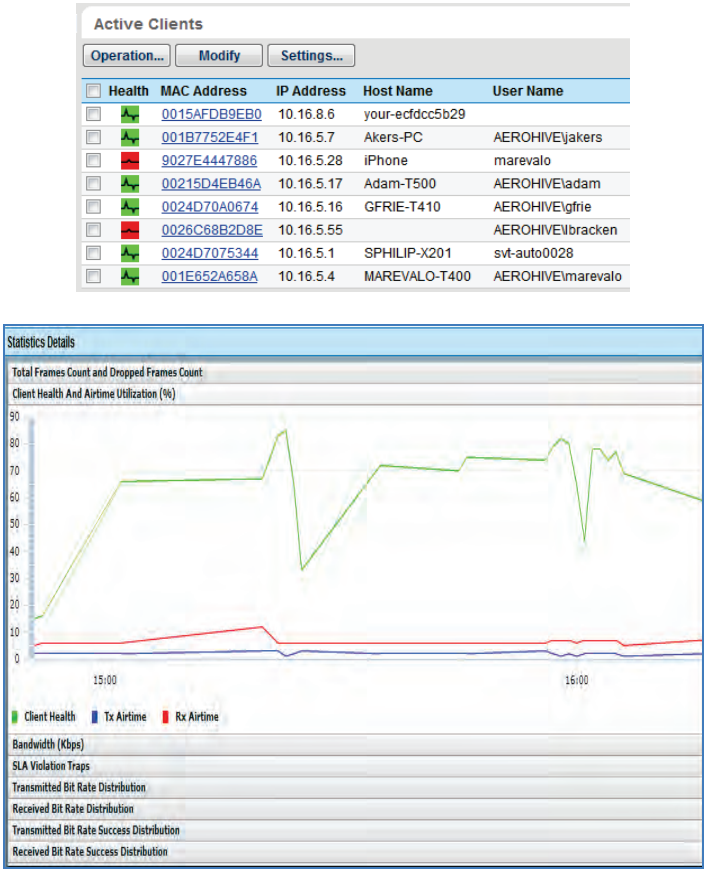

Figure 10: Client Health: Drilling Down Into Client Sessions

Service Level Assurance – An Example

Let's look at an example of the power and usefulness of Service Level Assurance features. In Figure 11, Group-1 has a client SLA of 6 Mbps, and Group-2 has a client SLA of 2 Mbps, but neither group has any SLA actions set. For that reason, all 6 client devices have similar throughput, although Group-1 clients are in violation of their SLA.

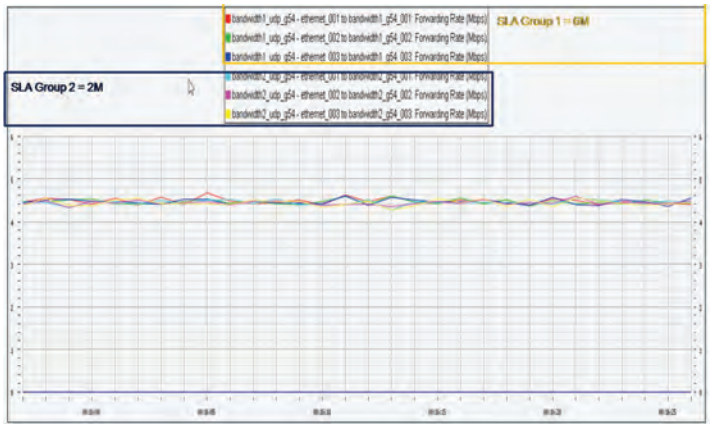

Figure 11: Example 1

In Figure 12, Airtime Boost is enabled. Group-1 clients are automatically given more airtime, which decreases the throughput for the clients in Group-2 but still keeps them performing above their SLA. In this scenario, the actions taken by Airtime Boost allow clients in Group-1 and Group-2 to achieve their SLA throughput levels.

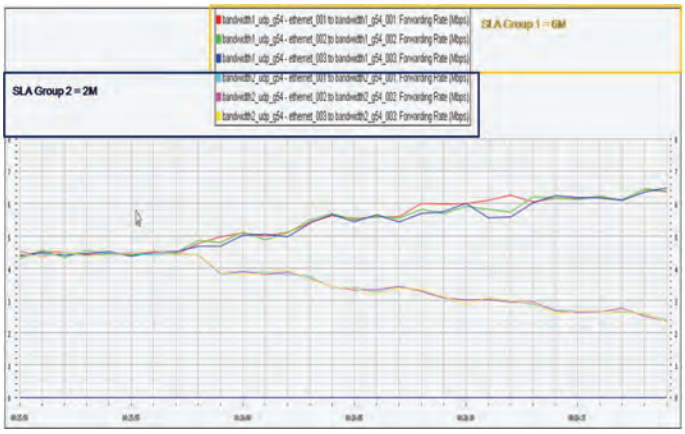

Figure 12: Example 2

It really is as simple as that. Sure, there's some rocket science behind it, but the administrator will never have to see all of those details. Making the magic happen is our job.

Configuration

In HiveManager's User Profile configuration section, it's only a matter of enabling the SLA feature with a click, choosing a throughput value, and then choosing your action from the list in the drop-down.

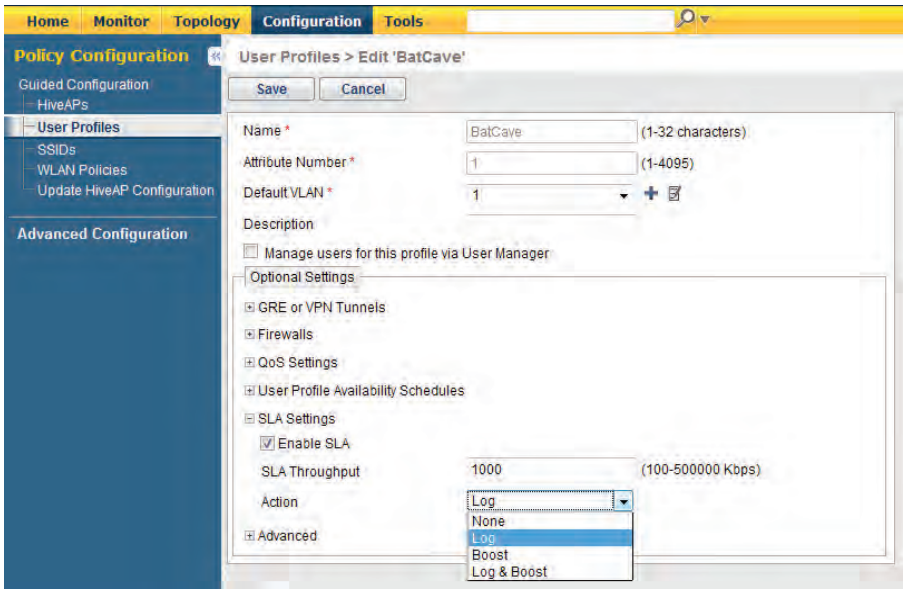

Figure 13: SLA Configuration in HiveManager's User Profile

This is a simple machine. We believe that when it comes to user interfaces, it's a matter of simplify or die.

Conclusion

Aerohive has again innovated to bring its customers market leadership in wireless determinism through performance guarantees, operational and architectural simplification, high-performance, and low cost. The ability to set SLA parameters per user group, to monitor SLA statistics in real-time, to monitor every client's health score individually or collectively, and to take significant corrective action when and where needed is an industry first and is included in Aerohive's Wi-Fi platform at no additional cost. The goal of delivering a level of wireless fidelity that allows applications to be moved from the wire to the air has been achieved. Now wireless can truly become the primary access layer.

About Aerohive

Aerohive Networks reduces the cost and complexity of today's networks with cloud-enabled, distributed Wi-Fi and routing solutions for enterprises and medium sized companies including branch offices and teleworkers. Aerohive's award-winning cooperative control Wi-Fi architecture, public or private cloud-enabled network management, routing and VPN solutions eliminate costly controllers and single points of failure. This gives its customers mission critical reliability with granular security and policy enforcement and the ability to start small and expand without limitations. Aerohive was founded in 2006 and is headquartered in Sunnyvale, Calif. The company's investors include Kleiner Perkins Caufield & Byers, Lightspeed Venture Partners, Northern Light Venture Capital and New Enterprise Associates, Inc. (NEA).

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