WHITE PAPER

THE WI-FI PERFORMANCE COMPANY

10 Factors Affecting Wi-Fi Performance

There are many factors affecting Wi-Fi performance in an enterprise, from the physical to the logical, from the interaction of protocols, and from things under one's control to things not under control. This article explores ten of these factors and is based on presentations delivered by 7SIGNAL engineers. A follow-on article which is entitled, **10 Steps to Optimize Wi-Fi Performance,** will discuss a systematic plan for improving Wi-Fi performance affected by these factors.

1. Antennas

Antenna design can have a fundamental impact on Wi-Fi coverage. It is important when assessing Wi-Fi performance to understand what antennas are being used in the access points. Typically antennas are built into access points and client equipment, but in more challenging physical environments, external antennas are used. Omnidirectional antennas are most typical and radiate in a 360 degree pattern from an access point; ceiling mounted APs typically have a downward tilt in order to reach clients located on the floor. But if the antennas, whether internal or external, are near some type of structure or like a metal grid or cement beam, that will that affect transmissions.

2. Power Levels

Somewhat hand in hand with antenna design is the transmit power level of the AP or clients. You have to be careful here, because the power is not always what the datasheet or controller settings tell you, and there are a lot of components that make up transmit power. For example, a radio transmitter on an access point may be capable of transmitting at only 8dBm at the highest data rate using HT40 channels. However, the antenna gain will provide another 3 dB, using HT20 versus HT40 will provide 2 dB, using lower data rates another 3 dB, and using MIMO another 3dB. Add this all up and you effectively get 20 dBm, which is what you might see on a data sheet. But keep in mind how we got this "gain" – operating at smaller bandwidth channels at lower dates using MIMO.

A lot of WLAN equipment has automatic power control algorithms. Typically, access points detect power levels of neighboring APs and try to optimize the cell size to create a matrix of barely overlapping cells. However, these algorithms tend to converge on a lower power level than necessary or desired, causing client coverage issues. It is often better to adjust the range of the transmit power control so that the minimum value is higher than the default

3. Channels

You may get all the physical factors right, with the AP placement, antennae design and power levels designed for optimal coverage, but still have issues due to logical problems such as channel assignment. There are some manufacturers that have invented their own protocol to enhance the basic Collision Avoidance in CSMA/CA but in general adjacent APs need to use different channels or else they will spend most of the time hearing everybody else and waiting to talk, which makes very ineffective use of the capacity. In the 2.4 GHz band, the channels are spaced every 5 MHz, but are 20 MHz wide, so there will be overlap unless adjacent APs (in North America) are on channels 1, 6 and 11. At 5 GHz, the channels are spaced every 20 MHz, so there is no issue using adjacent channels, however when you combine channels to get more bandwidths (e.g. HT 40) you need to make sure you don't create overlap.

4. Utilization

Another logical factor impacting performance is air-time utilization. There are three types of transmissions in Wi-Fi – data, control and management frames. Ideally, you want most of the capacity being used for data transmissions. However, if the network is supporting a large number of SSIDs, a lot of air time will be taken up by beaconing and probe responses. The beaconing rate also is a factor. We have found that keeping the number of SSIDs under five and extending the beaconing rate if possible from 100ms to 300ms significantly reduces management overhead and improves utilization.

5. Data Rates

The data rate used to transmit packets is tricky – ideally, we would like data to be transmitted as fast as possible, so the air is clear for the next transmission. However, all things being equal, it is harder to successfully transmit data at a higher data rate than a lower one. Since the transmitter is non-linear, it may actually use lower power to transmit the packet, and the receiver needs a higher signal to noise ratio to correctly receive the packet without error. If the packet is not received properly, it does not get acknowledged, and the transmitter has to retransmit the packet. Often times APs will quickly move down to a lower data rate to retransmit the packet if required. We have found that quite often it is better to start with the maximum data rate lower than the default maximum in order to cut down on retransmissions. Ultimately you want to create an optimum environment which uses relatively high data rates with relatively low retransmissions.

6. Legacy Support

802.11 is designed to be backward compatible with slower older devices running 802.11b, but this "legacy support" has a big impact. Not only do .11b packets take longer to transmit, but 802.11b clients can't detect the higher rate carrier of the subsequent standards, so the APs have to go into what is called "protection mode," which uses RTS/CTS control frames to grant the right to transmit. This adds even more overhead to the process. In practice, it is best to disable .11b – a lot of universities and enterprises are doing this, in hospitals, this is not so easy because of medical devices or VoIP badges still use .11b.

7. **Fragmentation and Aggregation**

Fragmentation is another factor that can improve performance in a noisy environment. By breaking up the packet into smaller fragments, there is a better chance of successful transmission all the fragments. It is the job of the receiver to reassemble the fragments into the original packet. The tradeoff is more overhead associated with each fragment. Aggregation is the concept of using a BLOCK acknowledgement to acknowledge a group of packets, thereby cutting down on the need to acknowledge every single packet. This helps increase efficiency at the expense of robustness.

8. **QoS Multimedia Extensions**

One mechanism for improving performance is to assign QoS traffic classes to help prioritize data within the network; a lot of times this gets translated to different SSIDs for Voice and Video, which are more delay sensitive. The 802.11 wireless multimedia extension (WME) can apply to both wired and wireless transport to provide an end-to-end mechanism for a class of service.

9. **Non-Wi-Fi Interference**

A lot of times when Wi-Fi is performing poorly, someone will first turn to the spectrum analyzer to find a culprit, but this can be a mistake. Wi-Fi can work in the presence of other radio interference, and before you start blaming blue tooth or microwave, it is important to understand the impact of the other factors involved mentioned here. That said, there can be bursts of interference, particularly in the 2.4 GHz level, so it is useful to measure the level of interference and try to correlate that with how the network was performing at the same time with a trending tool that can cover a large window.

10. **Higher Level Protocol**

The higher level protocol being used and its interaction with the 802.11 layer can have the appearance of affecting the Wi-Fi performance. For example, TCP/IP, which is used for file transfers and most web transactions, uses a slow-start mechanism to essentially test out the quality of the link. The TCP transmitter will send out a packet and wait for an acknowledgement from the TCP receiver. If it receives the acknowledgement within an allocated time, it will open up its transmission window and send 2 packets out, then 4, and so on. If at any time a lost or delayed packet or acknowledgment happens, TCP will close the transmission window quickly, making the connection look "slow." So network parameters such as packet loss and latency at the wireless level, or in the wired network, will impact the perceived speed of the Wi-Fi. UDP/IP, which is used for other type of protocols such as VoIP, does not use acknowledgements at the higher level; if a packet is delayed or lost, echo cancellers may get out of whack or the overall voice quality will seem noisy. This is why it important to test the network from an end-to-end perspective and segment Wi-Fi issues from wired issues.

These are some of the key factors impacting Wi-Fi performance. Read **10 Steps to Optimize Wi-Fi Performance** to discover what to do about them.

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