1.1.1.1

1.1.1.2 The Client

Wireless LAN Analysis

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2 Introduction

2.1 Purpose

This document introduces Simply Wireless' WLAN monitoring services.

2.2 Company Overview

Simply Wireless's unique focus in ***wireless networking*** solutions allows it to provide secure and scalable managed environments for the delivery of voice, video and data services across a multitude of wireless technologies – including Bluetooth, 802.11 and proprietary wireless LANs and WANs – to a broad range of mobile devices including desktops, laptops, PDAs, phones and handheld computers.

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4 Executive Summary

Simply Wireless was commissioned by the Client to undertake a limited analysis and evaluation of the client's Wireless Local Area Network (WLAN) infrastructure. Along with other factors, Simply Wireless Engineers found the wireless network to have been implemented using sub-optimal radio engineering practices and sub-optimal, wireless networking equipment given the requirements of a high-density organisation.

Such practices have resulted in degraded wireless network performance and in many cases a less than optimal end-user experience.

Compounding the poor radio frequency (RF) design, the Client's existing local area network (LAN) architecture further exacerbates the apparent performance problems though the lack of network segmentation and resultant large broadcast domains.

Whilst Simply Wireless have been informed that very few complaints are received regarding the wireless network, after having conducted a site inspection, Simply Wireless engineers attribute the user satisfaction levels to the low proportion of users seen actually utilising their laptops.

Overall Simply Wireless believes that given the current state of the Client wireless network and the compounding wired network design issues, the impending addition of 250 active wireless users and/or an increase in usage from existing wireless users may degrade the performance of the The Client wireless network to an unusable state.

5 Process Overview

Simply Wireless was commissioned by a client to undertake a limited analysis and evaluation of the client's Wireless Local Area Network (WLAN) infrastructure. The primary deliverable of the analysis was the identification of existing design shortcomings and an evaluation as to the suitability of the network to support an impending increase of users. The network evaluation was conducted in three phases.

5.1 Phase 1 – Initial interview

The interview was conducted as an exploratory discussion and analysis of the existing wireless infrastructure and technology. The discussion included, but was not limited to, exploring the status of the existing network; performance, coverage; suspected deficiencies, current network design and network management practices.

5.2 Phase 2 – Site Inspection

The site inspection consisted of an on-site analysis by two Simply Wireless engineers. The site inspection encompassed two campuses (senior and junior) and the existing 65+ access points across the Client campuses. The onsite analysis of the wireless network evaluated the RF design, network performance, utilised technology and overall health of the existing wireless.

5.3 Phase 3 – Findings Report

This report, as constructed by Simply Wireless engineers, contains detailed findings resulting from both the initial interview and observations made during the site inspection. The report will also list any recommendations from Simply Wireless engineers aimed at improving the performance of the existing wireless network.

With the aim of evaluating the wireless network under normal operational conditions, Simply Wireless engineers focused the scope of the analysis to four primary areas across two different days to obtain a realistic analysis of the wireless network performance. Areas and times included in the analysis are as follow.

6 Organisational Requirements

During the exploratory interview, Simply Wireless identified a number of organisational and technical requirements based upon the Information Technology (IT) Manager's experience and understanding of the usage, processes and procedures that exist with the Client.

Load Balancing for High Density Areas – Having implemented a combination of Orinoco and Enterasys access points, the IT department has noticed a significant lack of load balancing between access points. For example, in an area where 2 (two) access points exist in close proximity, the first may have between 0 (zero) and 5 (five) associated users whilst the second has in excess of 50 (fifty) users.

Video Delivery and Streaming – Whilst video streaming is not a requirement today, the organisation is looking into innovative ways to increase the pedagogical services provided by the wireless network.
As such, Simply Wireless has been asked to report on the health of the existing wireless network – keeping in mind the extra throughput requirements of Video on Demand services.

The Emergence of an additional 250 Users – As per the continued rollout of laptops to The Client's student population, The Client is expecting an increase of 250 users as of the commencement of Term 1, 2004. As such, the Wireless Network must be able to cater for the subsequent increase in Ethernet traffic.

Along with the specific requirements as set forth above, Simply Wireless's own experiences in the educational market have led to the identification of three key wireless implementation differentiators. As outlined below, these differentiators must be taken into account to take full advantage of the wireless network and avoid a degraded user experience.

High Density Cells – With classroom based cell sizes, a wireless solution must be able to service a large (25+) number of users in close proximity to each other and other wireless cells whilst maintaining a high effective Ethernet throughput rate.

Variable Cell Usage – Unlike an office where there may be an access point or two on an office floor to service the medium number of users as they wander in and out with their laptops, a school environment experiences scenarios where one classroom may be used by 25+ wireless clients, whilst next door there may be an access point in an empty classroom. Such inefficiencies should be reduced to take full advantage of spare RF spectrum and available bandwidth.

Extreme Mobility – When students move, they move en mass. A wireless network must be designed not only to cater for the above requirements, but to support a highly mobile user base. Reliable

roaming for mobile users ensures that data packets destined for highly mobile users are not lost, causing connectivity problems or network overhead through re-transmissions.

7 Quantitative Analysis

During the onsite analysis Simply Wireless engineers gathered information regarding the configuration, usage and signal dispersion of access points available from within the Client.

Utilising the captured frames, Simply Wireless engineers identified transmitted signals as either:
Data Frames – Uni-cast packets to or from wireless clients.
Broadcast Frames – Broadcast packets which are received by all clients on the The Client network.
Management Frames – Transmissions sent between wireless clients and access points to manage the flow of information.

From figure 1 (see below), Simply Wireless's prime area of concern is the proportionately high number of broadcast frames with respect to other frames captured across the wireless network. Broadcast frames are generated through the use of standard networking protocols such as DHCP and ARP and will consume the wireless network's finite bandwidth due to the poor subnet architecture. Simply Wireless utilises industry best practices as recommends that network broadcasts should not exceed 10%-15% of aggregate network traffic. Broadcasts across The Client network commonly accounted for between 15% and 25% of network traffic. These broadcasts have a significant effect on both wireless user data throughput and laptop battery life – resulting from increased CPU utilisation.

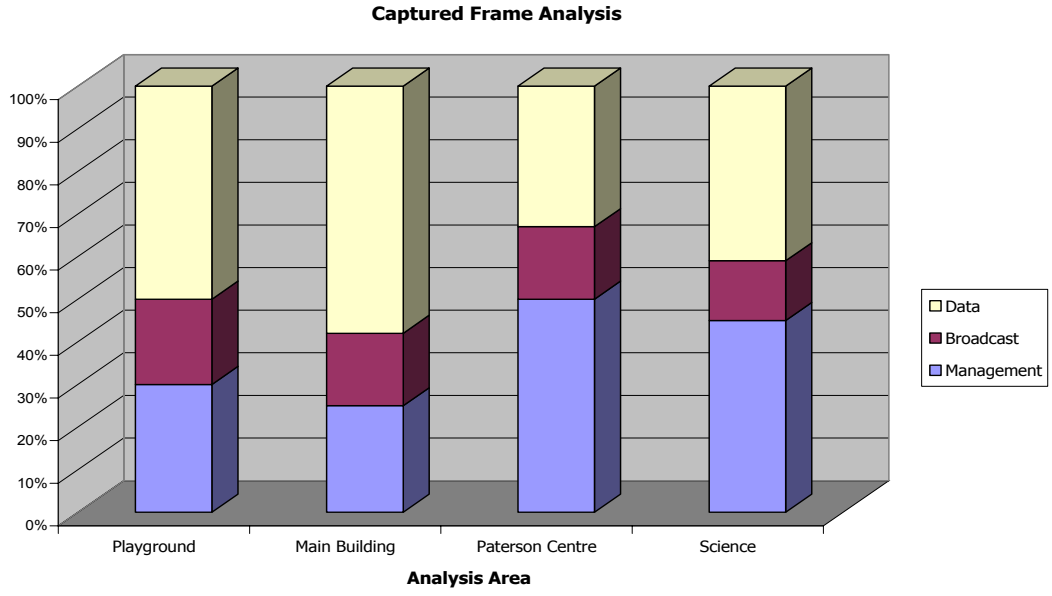

Figure 1 – Captured Frame Type Analysis

Simply Wireless engineers observed that whilst many users were able to receive a signal strength that under normal operation conditions should allow for the transmissions at 11Mbps, the majority of frames transmitted from both clients and access points were done so at 2Mbps. In order for 802.11b wireless clients to receive frames at 11Mbps, clients must obtain a signal strength greater than -84dBm[1] and a Signal to Noise ratio of greater than 15dBm.

Simply Wireless observed many users operating in areas of signal strength greater than -84dBm however due to poor RF spectrum management, additional access points had been configured to operate on either the same or overlapping channels as the primary access point for the particular area[2].

Simply Wireless attributes the disproportionately high number of 2Mbps frames to the RF "noise" generated by near-by access points on near or overlapping channels with unnecessarily high EIRP[3].

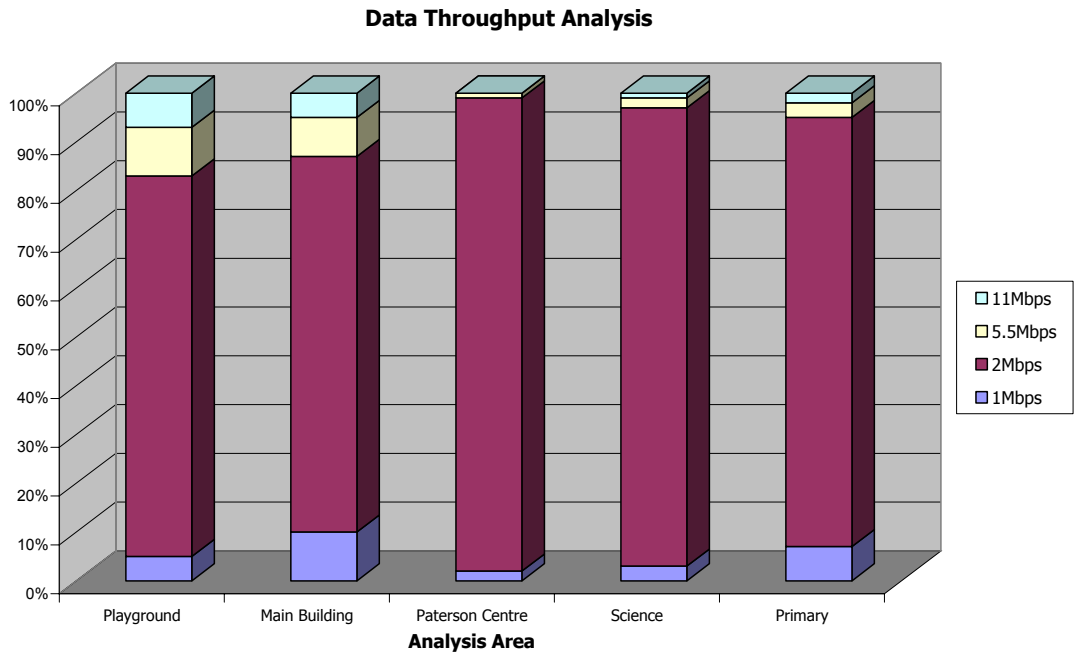

Figure 2 – An analysis of the wireless network transmission speeds.

[1] Clients must generally obtain a RSSI above -84dBm, however this may be alter slightly depending on the choice of client card.

[2] The use of identical channels for multiple access points is best practice, so long as sufficient thought is given to RF signal propagation in order to avoid RF signal interference in a contention based environment.

[3] Effective Isotropic Radiated Power – A measure of the signal strength emitted by a RF transceiver (eg. Access Point)

Utilising RF Spectrum best practices, an organisation should only utilise non-overlapping channels unless otherwise required[4]. Simply Wireless found that although The Client Client may have in excess of 6 access points available from any one area, the particular choice of channels may result in extraneous RF spectrum sharing.

802.11b example –

- Channel 1, Channel 6 and Channel 11 do not overlap or interfere with one another.
- Channel 4 will interfere with Channel 1 and Channel 6.
- An access point on channel 4 will reduce (share) the bandwidth of both the access points on Channel 1 and the access point on Channel 6.

The Client's wireless access points have been configured to utilise several overlapping channels, effectively increasing the number of access points that share the usable bandwidth to a level above the actual number of access points (see **Figure 3**).

Given the recommendation of non-overlapping channels for a best practice wireless implementation, Simply Wireless has broken down the spectrum into three areas for the purposes of a spectrum utilisation analysis.

2.402 GHz to 2.432 GHz – For access points assigned to Channel 1, any wireless device operating within this part of the spectrum forces the Channel 1 access points to share the spectrum and reduces the available bandwidth per access point.

2.407 GHz to 2.462 GHz – For access points assigned to Channel 6, any wireless device operating within this part of the spectrum forces the Channel 6 access points to share the spectrum and reduces the available bandwidth per access point.

2.442 GHz to 2.487 GHz – For access points assigned to Channel 11, any wireless device operating within this part of the spectrum forces the Channel 11 access points to share the spectrum and reduces the available bandwidth per access point.

[4] For example, coexistence with other technologies operating in the same part of the spectrum such as Bluetooth and 802.11b/g.

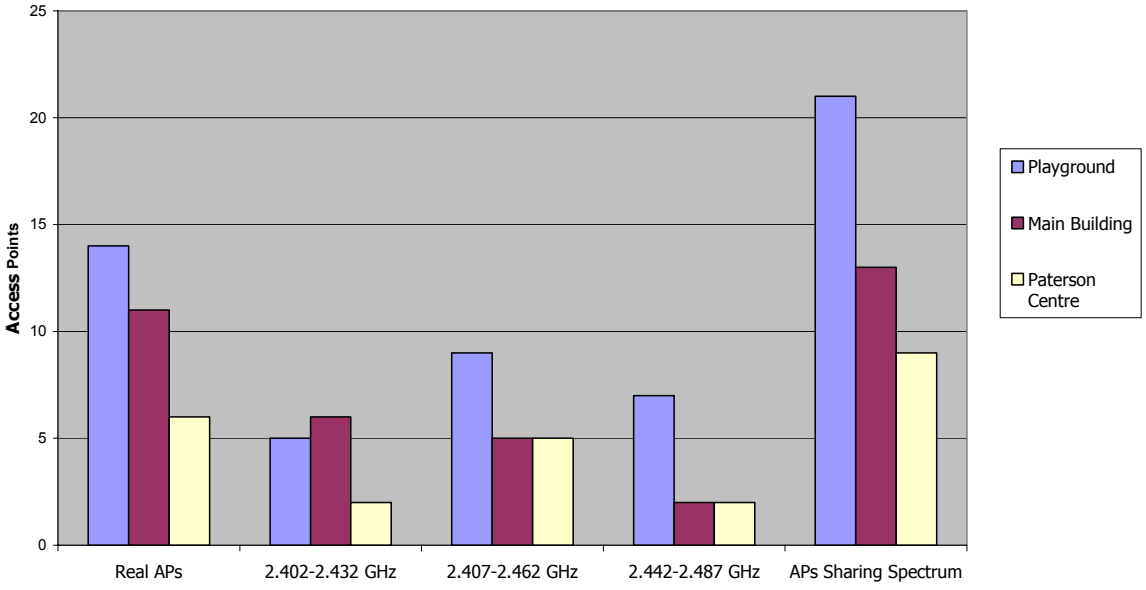

Figure 3 – Effective Spectrum Degradation due to RF Configuration.

Simply Wireless cannot stress enough the importance of effective RF spectrum management. Due to the contention-based nature of wireless technologies, where two (or more) RF transceivers operate in the same geographic location, and are configured to operate on similar (or overlapping) channels, the maximum throughput under load is reduced in proportion to the number of active transceivers.

During the onsite inspection Simply Wireless engineers identified many access points operating on overlapping channels, greatly reducing the maximum bandwidth available for wireless clients associated with each access point.

Figure 4 (below) takes into account the recorded number of access points in each areas, in each part of the spectrum and shows the efficiency of such access points were they to be utilised simultaneously.

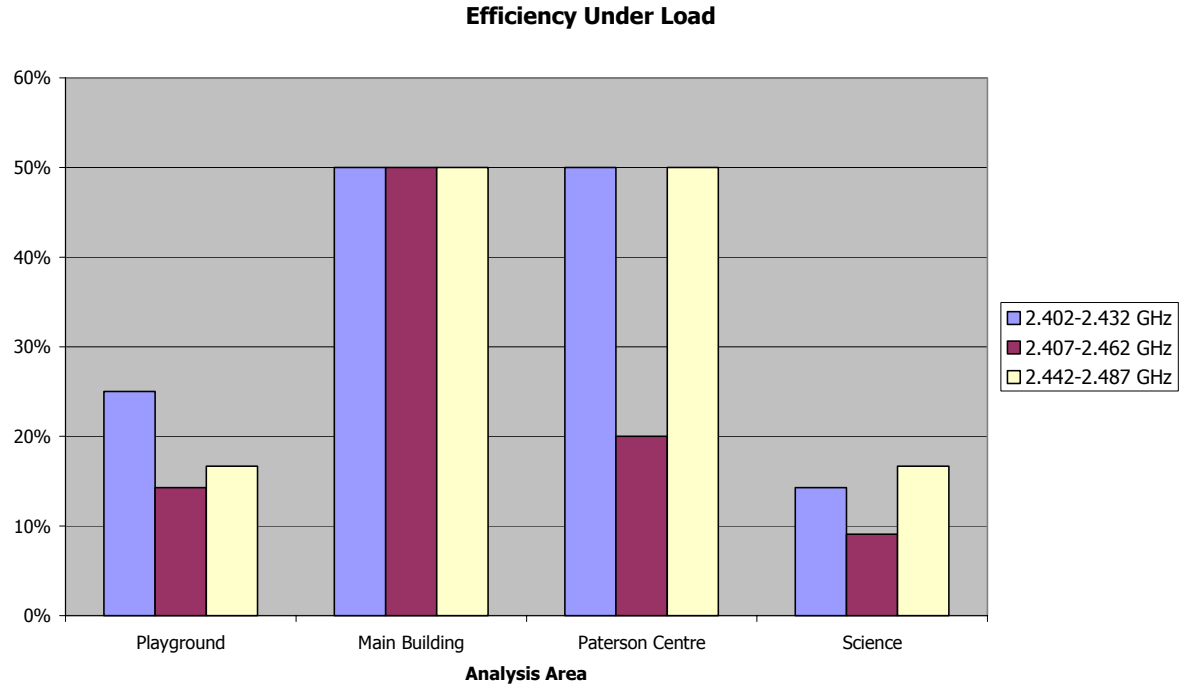

Figure 4 – Access Point Efficiency due to Multiple Overlapping Cells

8 Requirement Responses

Given the requirements set forth during the interview and the subsequent quantitative analysis, Simply Wireless asserts the following.

Load Balancing for High Density Areas – Due to the brand choice and heterogeneous nature of the current The Client wireless infrastructure, the equipment is not capable of any form of intelligent load balancing.

Video Delivery and Streaming – Common Video on Demand (VoD) techniques utilise between 150kbps and 300kbps per user. Given the current status of the Client wireless network, Simply Wireless does not believe the Wireless LAN to be capable of supporting such a large increase in bandwidth utilisation. Also, given the flat network architecture, overlapping cell and overlapping channel nature of the current RF design, the utilisation of streaming video in one area will greatly affect the wireless network in both the surrounding areas and possible the network as a whole.

The Emergence of an Additional 250 Users – Simply Wireless does not believe the current network capable of supporting the existing user base should the number of simultaneous active users increase and as such Simply Wireless strongly advises against the addition of an additional 250 users onto the existing wireless network. However, given Simply Wireless's observations during its limited onsite analysis, Simply Wireless engineers are unable to ascertain the number of active wireless clients at any point in time and the exact corresponding network affect.

High Density Cells – The The Client wireless network was initially deployed using a generalised ratio of 2 classrooms per 1 access point. Given that The Client may have between 20 and 30 users per classroom, the effective number of users on any one access point may be between 40 and 60 users. Utilising vendor recommendations, personal experience and other customer experiences, Simply Wireless recommends that the maximum number of medium-usage[5] users per access point be between 15 and 25 users – effectively recommending 1 access point per classroom.

Extreme Mobility – Due to the brand choice and heterogeneous nature of the current The Client wireless infrastructure, the equipment is not capable of any form of ubiquitous Layer 2 (Data link / RF Layer) or Layer 3 (Network Layer) roaming. The affects of insufficient layer 2 roaming can be seen when wireless clients fail to change associations and associate to the strongest wireless signal or experience decreased throughput (slow network response times) due to data retransmissions as clients roam between access points and data is not routed to the correct access point for delivery. The lack of Layer 2 roaming can also result in the wireless users experiencing 'drop-outs' as their cards

[5] Simply Wireless defines medium usage users as those who frequently access medium sized internet based information, personal and/or shared Microsoft Office (or similar files) and other files that tend not to exceed approximately 2MB in size.

drop an association from one access point due to the loss of signal after which it must initiate a scan for the next available access-point. A wireless network designed for Layer 2 roaming will ensure that wireless clients seamlessly migrate to an alternate access point prior to the signal from the first access point is lost.

9 Recommendations

Simply Wireless recommends the following in order to improve the health of the Client wireless network given the limitation of the exiting equipment.

Network Architecture Design – Through the utilisation of the available 3Com Layer 3 switch and the implementation of multiple network subnets, The Client can effectively reduce the number of users per broadcast domain, reducing the proportion of network broadcast packets being emitted across the wireless LAN. The reduction in broadcast packets across the wireless LAN increases spectrum availability and provides for faster network response times.

Radio Frequency Spectrum Design – Simply Wireless highly recommends a strategic and progressive approach to the correction of the existing RF design problems. Through proper coverage mapping and RF design, The Client will be able to significantly increase the capacity and usability of the wireless network. This increase in capacity will ensure that the addition of new active wireless users will not compromise the user's network access. Simply Wireless believes that through correct RF planning, The Client will be able to significantly alleviate problems such as; extraneous spectrum sharing, substandard wireless data transfer rates and decreased access point efficiency.

Appendix 1 includes information regarding Simply Wireless's industry leading professional RF Planning Site Surveys for Wireless LANs and includes information regarding some of the techniques Simply Wireless will utilise to increase the health of the existing The Client wireless network.

Proactive Monitoring – Both Simply Wireless and the Client Information Technology Manager have identified the need for proactive monitoring for the wireless network. Proactive monitoring allows an organisation to be notified when an access point (or other device) becomes unavailable. Along with operational state, proactive monitoring allows for the identification of network bottlenecks and over-utilisation which can degrade network performance, allowing for corrective measures to be put in place prior to an avoidable network failure.

Whilst not included as an Appendix, Simply Wireless offers 'Remote Monitoring' to many organisations for just such a requirement. Remote (pro-active) monitoring allows Simply Wireless to support an organisations network in a timely manner whilst providing real-time information allowing both Simply Wireless and the organisation to best plan for future upgrades or rectify problems identified through active network analysis. Simply Wireless is happy to provide further details regarding the specifics and availability of this service.

10 Appendix 1 – WLAN Site Survey

Radio Frequency (RF) Site Survey
for Optimum Wireless LAN Performance

Introduction

As companies extend their existing networking infrastructure to include wireless networks, they will need to thoroughly define how wireless technology will be utilised within their organisation.

For most companies Wireless Local Area Networks (WLAN's) must be more extensive than the existing wired network (LAN), handle an equivalent level of data and provide continuous, clear and reliable signal coverage.

The Importance of a Site Survey

The primary objective of a **Site Survey** is to ensure that all users of the WLAN do not experience "drop-outs" or "black-spots", which could potentially cause irreversible data loss, as users roam within the WLAN infrastructure.

The Site Survey will also report the potential impact of the adding a WLAN to your existing wired LAN.

Performing a Site Survey provides us with a realistic understanding of infrastructure required for a given wireless network. The Survey can also assist in predicting trends in network traffic, indicate high load areas and resolve difficult RF interference issues from existing devices or neighbouring sites. The collation of all this data enables Simply Wireless to provide accurate pricing, a complete network design and all required security recommendations.

Simply Wireless' engineers will consider five major areas while conducting a Site Survey.

1. Range and Coverage Analysis

Range and Coverage Analysis is the first phase in the survey process. Our engineers will use 802.11 diagnostics software and custom built RF hardware to define range constraints for your network environment. By taking into account issues such as signal propagation, LOS (Line of Sight) analysis and Signal Shaping, our engineers can determine which type of access point and antenna pairing is best suited for your environment.

Figure 5 – An example floor plan overlaid with our WLAN signal coverage analysis

Areas with coverage can be seen in red.

2. Multi-path Fading Analysis

Multi-path Fading Analysis is the second phase in a Site Survey. Our engineers will analyse all objects and obstacles that may inhibit (attenuate) the wireless signal, such as metal objects, concrete or brick walls, etc. The positioning of access points will be determined based on the location of any obstacles in order to obtain the maximum signal strength to all required areas throughout your organisation.

3. Interference and Dampening Analysis

Interference and Dampening Analysis is another crucial phase of the Site Survey. Our engineers will use amplified multi-frequency receivers to detect any opposing signals in the local 2.4 GHz or 5.3 / 5.8 GHz spectrums. This could include high power microwave ovens, long range cordless phones, or even existing wireless networks. Our engineers will measure the interference caused by these devices and assess the effect on your wireless network. As required compensation calculations will be made so that the final implementation will operate flawlessly.

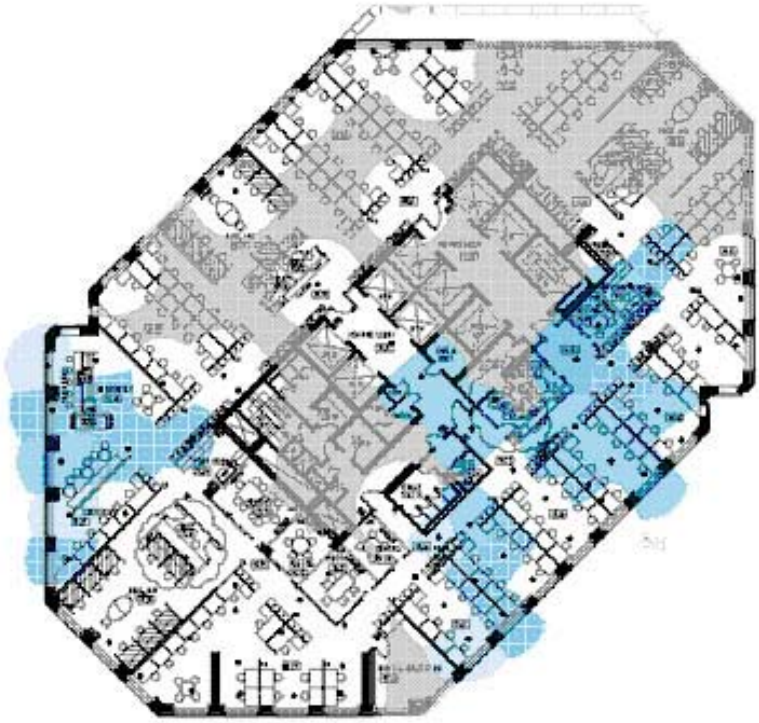

Figure 6 – An example floor plan overlaid with our WLAN interference analysis.

Areas with interference can be seen in blue.

4. Legacy Cohesion Analysis

Legacy Cohesion Analysis is an integral part of the Site Survey analysis. Our engineers will take a close look at the existing network in your company and document all significant criteria that may affect the installation of a wireless network. Items such as types of operating systems, server configuration, security policies and user collaboration will all be taken into account at during this phase. This process ensures that the installation will run smoothly and with minimal unforeseen variables. In addition Simply Wireless can also integrate custom corporate software into any wireless networking solution.

5. Bandwidth Requirements Analysis

Simply Wireless engineers will discuss any network throughput or bandwidth requirements of your WLAN implementation as well as perform an evaluation whilst onsite. Through Bandwidth Analysis our wireless network engineers will unlock any potential bottlenecks in the proposed system and look to increase bandwidth for particular sectors that have greater connectivity needs.

Figure 7 shows the initial stage of a Site Survey - as the diagram shows the example site is high in RF obstacles and signal propagation (spread) is poor. Large coverage gaps appear which will cause drop outs and black spots even if the client is in close proximity to the access point.

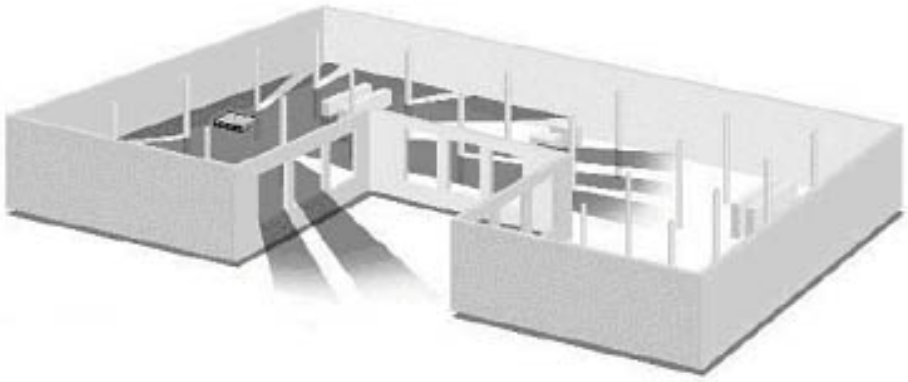

Figure 7

As shown in ***Figure 8***, black spots can be eliminated and full coverage achieved via the precise placement of the access points.

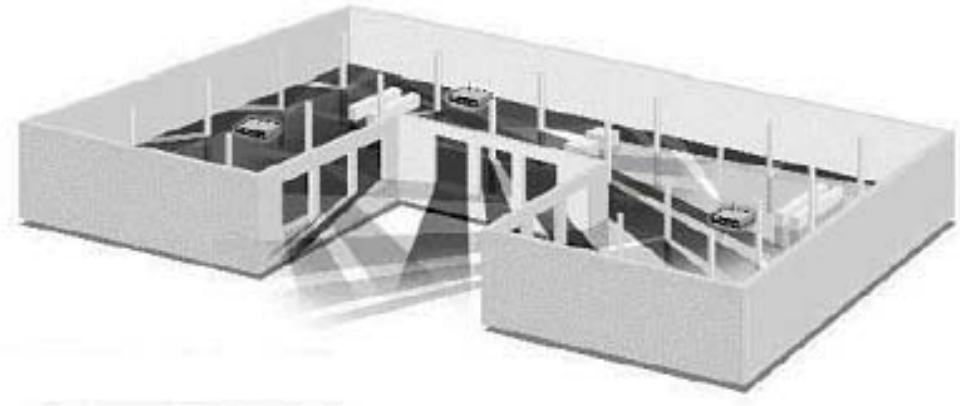

Figure 8

The role of the Antenna is of paramount importance – by using different antennas the engineer can modify the coverage pattern of the access point. This is crucial in order to allow for maximum density of clients (end user PC's), maximum signal reception and to reduce external signal leakage. Antennas can be divided into two logical categories:

1. Omni-Directional Antennas have a torus-shaped propagation pattern in 360°, this looks very similar to a doughnut shape. Omni–Directional Antennas come in several different types; **Plane Antennas, Diploe Antennas** and **Rubber Ducky Antennas**. The Plane and Diploe are usually used when the base station requires radiation in all directions.

2. Directional Antennas concentrate RF in a particular direction. This produces a conical-shaped or flashlight-shaped pattern. Different Directional Antennas are described by their beam width and gain. The most common type of directional antennae are; **Parabolic Dish Antennas**, **Yagi Antennas**, **Sector Antennas**, **Patch Antennas** and **Panel Antennas**

Yagi and Parabolic Dish antennas are used mainly in outdoor, building-to-building installs or for coverage down a long corridor. Parabolic Dishes usually have a beamwidth of a few degrees and a gain from 20 to 30dBi. Yagi Antennas, on the other hand, have a beamwidth of between 10 to 30 degrees and a gain from 10 to 20 dBi.

Sector, Patch and Panel antennas are commonly used in indoor installations. They allow increased range of an access point and are particularly versatile from an installation location point of view. Sector Antennas usually have around 180 degree beamwidth and a gain from 3 to 10dBi. Patch Antennas and Panel Antennas have minimal gain and are used to better 'shape' the wireless signal.

Calculating Antenna Coverage

The use of an antenna to increase signal strength is called Antenna Gain and is measured in decibels (dB). Gain improves the coverage area of an access point. For a 1dB increase in the gain, the coverage of an indoor access point is increased by approximate 2.5%. For a 1dB increase in the gain, the coverage of an indoor access point is increased by approximate 5%. These figures can vary depending on the number and size of obstacles.

Use of Diversity Antennae to Increase Performance

Diversity is where the radio can switch between different antennas to minimise interference and noise due to multi-path signals. Diversity allows the radio to reconstruct the best signal using two or more different antennae.

Positioning Antennas for Best Results

Positioning and orientation of the antenna ultimately determines the eventual performance of any given WLAN - factors such as line of sight, obstacles and other issues (as discussed above) are directly related to performance of the WLAN. Our engineers have all of the relevant training and experience enabling them to find the right series of Access Point locations for your site.

Simply Results

Once the Site Survey is completed, the Simply Wireless engineer will collate all the information gathered to produce a professional **Site Survey Report**.

This report contains such information as General Recommendations, Specific Recommendations related to your site, a detailed Coverage Map of the area to be covered, Interference Problem Areas, all the Equipment required to perform the installation and the proposed configuration for each access point.

Simply Wireless Site Survey fully guarantees signal coverage in the areas described in the Report for a 30 day period (subject to terms and conditions).

Simply Wireless prides itself on the quality of its Site Surveys - the report is extensive, detailed and accurate. We look forward to helping your company make the most of its wireless infrastructure.