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A Guide to Choosing the Right Wireless System for your Primary School

Primary Wireless Solutions

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MANAGEMENT SUMMARY

INTRODUCTION

Wireless networks are now widely used across many industries and are becoming more advanced by the week. Most of us will come into contact with wireless technology every day without realising it. In the education sector wireless can deliver real educational benefits, promoting greater flexibility in teaching, enabling mobile learning and encouraging better pupil engagement.

But choosing a wireless system can be a daunting task with a wide range of different systems and equipment all claiming to offer different features and benefits. This guide aims to explain how wireless systems work and some of the pitfalls to look out for, the different types of system available and how to make the right choice for your school.

The first section of this guide, 'CHOOSING THE RIGHT SYSTEM FOR YOUR SCHOOL', has been written with school decision makers and ICT Coordinators in mind and although there is some technical content, this has been kept to a minimum to assist in explaining the considerations that should be made.

If you want to know more about how wireless works then the second section of this guide, 'UNDERSTANDING WIRELESS SYSTEMS', is for you. This section uses examples of a typical primary school setup to help explain technical concepts in more detail and provides advice on how to avoid or mitigate common problems.

Once you have read this guide you will have the necessary knowledge to identify how your school will use wireless, how many users you need to support, the type of system that will best meet the school's needs and how you need to manage users and secure the wireless network.

The information you collate can then be passed on to the providers of your choice to design a wireless solution for your school. By taking professional advice you can be confident that your new wireless system will meet the school's current needs and can be upgraded to account for future demands when the time is right.

We hope you find this guide useful and informative and welcome any questions or comments you have.

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CHOOSING THE RIGHT SYSTEM FOR YOUR SCHOOL

How many devices will connect?
The number of client devices you intend to connect to your wireless network will determine the minimum number of Wireless Access Points (WAP's) required to deliver reliable service. The other main factor to consider is where these devices will be used. Large groups of devices in a single location will place a higher demand on your wireless network than they would if spread evenly across your site. It is important to consider how this might change in the future too. You may need to add more WAP's over time as you add devices so make sure you choose a system that supports future upgrades.

How will the system be used?
For many schools, wireless provides access to the same services available through the wired network. This may include a user's files, shared resources, printing, network applications, e-mail and internet. In some cases the wireless may only be used for internet based research. Wireless can also provide additional features such as guest access where visitors to the school can be given internet access whilst on site. Where the school intends to access a full range of services, a greater number of WAP's may be required to ensure good user performance. Actions such as pupils Logging on and off the network at the same time can create significant volumes of data which will impact on wireless performance. With careful planning this can be mitigated to a point, but wireless performance will never be comparable with wired network performance with currently available technologies.

Un-managed vs. Managed
If you have less than 10 WAP's and will only have up to 10 user devices connecting to each WAP you could go for an un-managed wireless system and will find the capital cost of an un-managed system is attractive when compared to a managed system. As discussed later in this guide, there are a number of limitations to an un-managed system and performance will be inferior to that of a managed system. You should also consider the cost and complexity of supporting an un-managed system over the life of the solution as a managed system may deliver a lower Total Cost of Ownership over a 5 year period and you will also benefit from the additional reliability and features a managed system can offer. Remember that all wireless systems can be phased in over time, expanding as budget permits. You may be able to identify key areas that need wireless now and others that would benefit from wireless but are not essential right now.

Single vs. Dual Band
If budget is very restricted you may want to consider a single band system but as discussed later in this guide, you are likely to experience congestion problems as wireless use increases. If you opt for single band then go for a managed system to give you the best possible levels of reliability. The difference in WAP cost is relatively small but the system will provide users with a much better wireless experience.
If budget permits go for a dual band system. This offers a greater level of 'future-proofing', gives superior performance over single band wireless and delivers higher bandwidth to users. Dual band systems are better suited to supporting high user device density where some or all of the user devices have a dual band wireless network card fitted.

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Fixed vs. Mobile WAP's

Most wireless systems employ WAP's installed to fixed locations around the building providing coverage to specific areas. Where increased user device density is required, additional WAP's are installed to the required areas to support the additional devices. Fixed systems are always ready to use and no user intervention is required.

An alternative solution is to fix the WAP's to portable device storage trolleys that move around with the user devices. This has the advantage of ensuring there is always sufficient coverage and support for the required user devices. The main disadvantage of the mobile system is the user has to make the necessary power and network connections at each location the trolley moves to.

It is possible to mix fixed and mobile solutions, however this often results in wireless interference issues and compromised performance. The most reliable way to mix the two systems is to set all fixed WAPs' on one band (e.g. 5GHz) and all mobile WAP's on the other (e.g. 2.4GHz).

Configuring WAP's

Whether you choose an un-managed or managed system, the WAP's will need to be configured to work with the school network. For un-managed WAP's each will be configured separately and a cabled connection to each WAP will be required. Managed WAP's are configured concurrently from a central controller console.

There are a wide range of configuration options and most schools prefer to leave this element of the installation to a qualified engineer. The engineer will be able to test the installed system too ensuring it is functioning correctly.

Security

Data security is critical in a school environment and there are increased risks presented by installing a wireless system. With a conventional wired network, an individual would have to be inside the school building to connect a device to the network. With wireless systems, as explored later in this guide, radio signals may propagate outside the school building and possibly outside the school grounds. This means the school network may be 'visible' from outside the school and is no longer protected by physical security (locked gates, doors etc.).

Un-managed wireless systems will include as a minimum at least 2 network access control mechanisms to prevent unauthorised access. Unfortunately it is common to find wireless networks where these have not been implemented adequately. Managed wireless systems will include many more layers of security with different configurations possible for multiple groups of users.

You should ensure that any wireless network that could potentially enable access to personal data is secured from unauthorised access. Any guest access provided should be limited to internet access only. A qualified engineer will be able to advise you on the best way to secure your wireless network.

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Mobile Device Management

Bring your own Device or BYOD is becoming increasingly popular with educational establishments. Users are allowed to access the network using their own device rather than one provided by the school. This can have the advantage of allowing more users to have access to devices in class than the school could provide and users will be more familiar with their own device. But allowing a diverse range of devices to connect to your network brings new challenges. Mobile Device Management (MDM) software provides the ability to manage non-school devices connecting to the school network. This can include checking the device for valid anti-virus software before granting access. It will also be possible to prevent non-educational applications from being run while the device is connected to the school network. MDM will usually work on Windows, Android and Apple IOS devices. Some managed wireless systems include MDM as standard or it can be purchased as an additional 'bolt on' package on a per device basis.

Get Advice

To help you make the right choice for your school it is best to seek advice from several companies who specialise in wireless systems for education. This will give you a balanced view and a choice of different wireless systems capable of meeting your requirements. Before you get advice, make sure you are clear on what you expect from your wireless system, how you intend to use it and how many devices need to connect in each area. This will ensure you are offered a suitable solution. You should also ask for quotations to include the costs of installation and configuration of the system, including power provision for WAP's, and on-going support if this is required. This will give you a selection of like for like quotations to compare.

All you need to do then is decide which company you feel adds the greatest value and can form a long term partnership with your school supporting you where necessary.

UNDERSTANDING WIRELESS SYSTEMS

Wireless Technology

Wireless Networking systems operate over two frequency bands within the UK using the 2.400GHz to 2.500GHz and 5.170GHz to 5.710GHz frequency ranges. These frequency ranges fall within the ISM band (Industrial, Scientific and Medical band) which is internationally reserved for the use of radio frequency (RF) energy for industrial, scientific and medical purposes other than telecommunications and can be used without a license.

Older wireless network systems operate on the 2.4GHz band only, and this is the most commonly utilised frequency range across a wide range of consumer devices. This is also referred to as 'Single Band' wireless. Examples include wireless printers, smart phones and cordless telephones. Many IT devices include wireless network cards utilising the 2.4GHz range and this may include older user devices the school may have. The main disadvantage of the 2.4GHz band is that it can become very congested due to the number of products using this technology. Due to the unique nature of network usage patterns in school, for example a whole class logging on or printing together at various points in the lesson, this often results in perceived 'slow' wireless performance or erratic connection to wireless. The main advantage of the 2.4GHz band is a wide choice of equipment at a much lower cost when compared to 5GHz technology.
Wireless standards utilising the 2.4GHz range are 802.11b, g and n.

Newer wireless network systems may offer a second radio operating on the 5GHz range in conjunction with a 2.4GHz radio. This is also referred to as 'Dual Band' wireless. Because the 5GHz band is less commonly used in consumer products, and tends to be found only on 'high end' user devices and products, this has the advantage of being less susceptible to congestion and is able to deliver faster connections providing greater throughput to compatible user devices. The main disadvantages of the 5GHz band are higher equipment costs and it delivers less range of coverage than the 2.4GHz band, although this will not be relevant in cases with smaller school buildings. The main advantages of the 5GHz band are greater performance, connection reliability and greater user capacity.
Wireless standards utilising the 5GHz range are 802.11a, n and ac.

There are essentially two types of wireless architecture in widespread use today, the most common being multi-channel where WAP's utilise different channels to avoid interference and build up a 'mesh' across the site. Less common is single channel architecture with WAP's all utilising the same channel to build up a 'cloud' across the site. Both architectures should provide reliable operation if correctly designed and configured.

Device Capacity
A device or user device is the hardware that allows a user to connect to the network. This may include desktop PC's, Laptops/Notebooks, Netbooks, iPad's or mobile phones.
A typical single band 2.4GHz access point is likely to provide effective capacity for up to 10 devices concurrently.
A typical dual band 2.4GHz & 5GHz access point operating at 5GHz is likely to provide effective capacity for up to 20 devices concurrently.
Modern enterprise grade managed wireless systems are capable of supporting between 100% and 150% more devices per WAP.

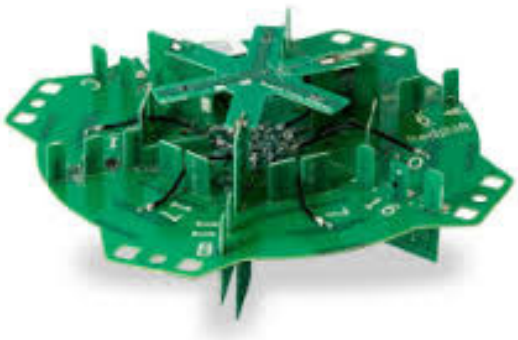
Wireless Access Point (WAP)

The wireless access point, or WAP, is the radio transmitter/receiver that allows user devices to connect to the school network wirelessly. Each WAP requires a wired network connection to the school network and a power source.

Wireless Access Points come in a variety of shapes and sizes and may have internal or external antennae.




On more advanced WAP's an internal antenna array is used to improve range and performance.




The WAP can be mounted on a solid wall or suspended ceiling and will need a network point ideally located within 2 metres. Alternatively the WAP can be semi-portable, for example on a notebook trolley, and connected into existing network points in each location.

Power can be provided by a power supply, similar to a laptop power supply, next to each WAP or by using a technology called Power over Ethernet or PoE. This uses the spare wires in a network cable to carry power from a central point, usually located in the main network cabinet, and deliver the power direct into the wired network adapter on the WAP. Some network switches can provide PoE or alternatively PoE injectors can be used.

Un-managed Systems
Where lower cost standalone WAP's are used to create a wireless network, each need to be configured individually. This can be quite time consuming on larger networks and careful planning is required to ensure the network functions correctly. Although the WAP's will be aware of each other, there is no management or monitoring information exchanged between them and therefore they are not able to proactively change settings to manage signal quality and interference issues. Some models will be able to load balance client devices between WAP's to ensure each client has sufficient bandwidth but the effectiveness can be variable.
Un-managed systems are best suited to small deployments with lower client device numbers and are often purchased where budget is the main factor in choosing a solution.

Managed Systems
Higher cost enterprise managed wireless systems utilise a physical on site or externally hosted controller to manage the wireless network. The WAP's may be semi-intelligent (able to function in their own right) or may be a transmitter/receiver only with all the configuration and management handled at the controller level. A managed system offers centralised administration and the configuration is done once from a central console and then sent to all the WAP's. Unlike an un-managed system the WAP's are in constant communication through the controller and are able to monitor signal quality, detect sources of interference and reconfigure radio settings proactively to ensure client devices have a reliable connection. Client load balancing is very effective and will take into account bandwidth usage and client device wireless network card type to distribute client devices between WAP's.
Managed systems are best suited to larger deployments or networks with higher client device numbers and are often purchased where performance is the main factor in choosing a solution. Although the initial capital outlay will be higher the true cost over the life of the system is likely to compare favourably against a similar sized un-managed system.

Mobile Device Management
Some managed systems offer the additional benefit of providing mobile device management (MDM) software and features. This will help to keep track of the school's assets and allows restrictions to be applied across a wide range of devices whether Windows, IOS or Android based. The same MDM software can also be used to deploy applications to user devices and track their usage and physical location. Most MDM software offers the facility to remotely erase a user device if it lost or stolen to prevent access to any data held on the device.

Client Density
When designing a wireless system the expected numbers of current and future users, needs to be considered. The number of client devices in any given area is referred to as client density. For example if the school has 30 client devices and uses them in groups of 2 or 3 across the school, only sufficient WAP's to provide coverage would be required. If the school wishes to add a further 30 client devices and use them in class sets of 30 devices in adjacent classrooms, a larger number of WAP's would be required to ensure reliable connections and bandwidth. Generally speaking, the higher the client density, the greater number of WAP's required.

Sources of Radio Interference

Any Radio device transmitting on the same frequency band as a wireless network or at high signal levels on different frequency band may cause interference and will impact on the reliability and performance of the school's wireless system. It should be noted that in addition to devices used inside school, sources of interference may also come from outside the school.

Because most schools are located within residential areas, one of the main aspects to consider is the use of home wireless systems with many homes now having a wireless broadband router. Although these are positioned inside the residential premises, it is common to find them positioned close to windows. In free space the effective range of home wireless systems can be up to 350 metres.

The Google Maps view of a typical primary school shown in Fig.1 below gives an indication of the possible spread of radio waves from wireless devices in neighbouring residential premises. Conversely we also need to consider the possible impact the school wireless network could have on the surrounding residential area.

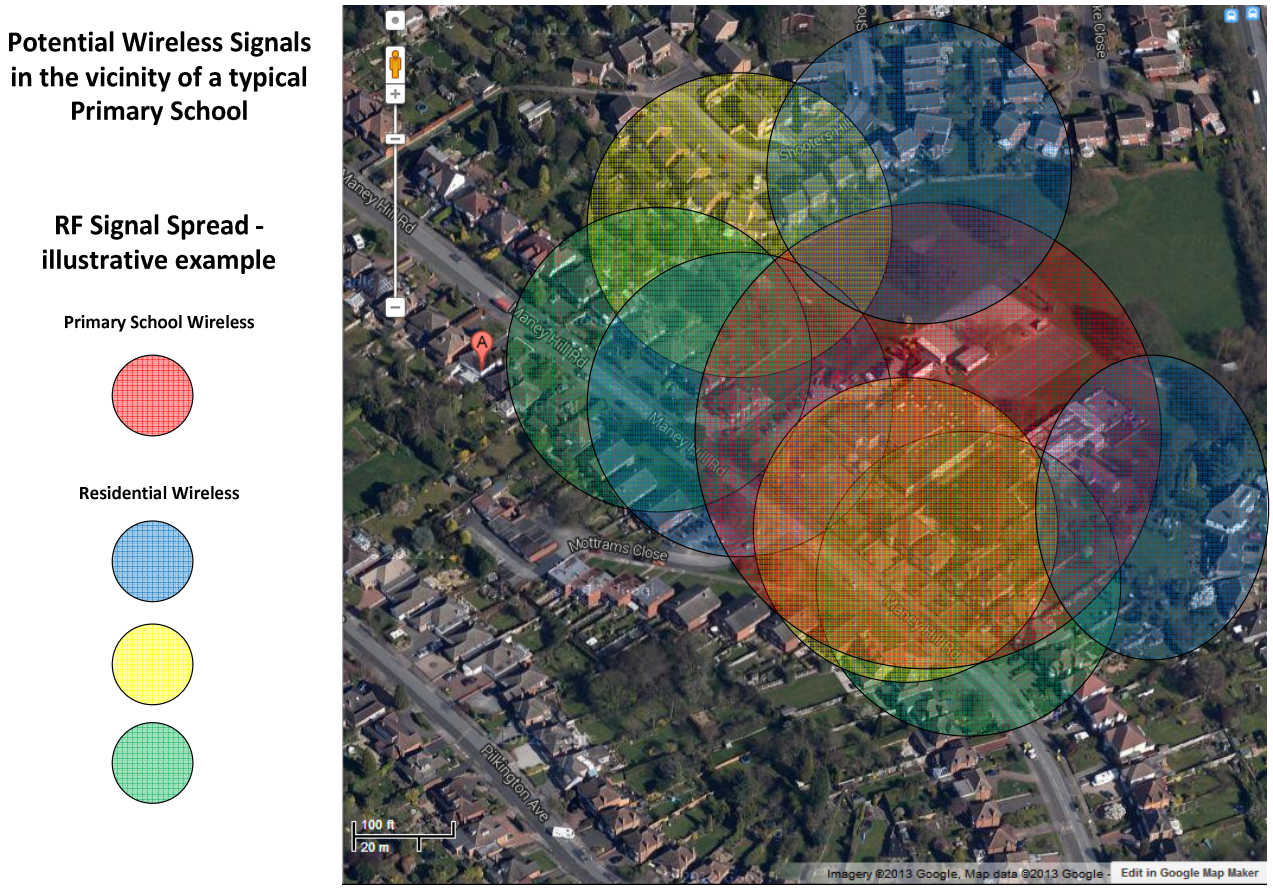


Fig.1 Potential Wireless Signals near the School

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One of the most common sources of internal interference encountered is the microwave oven. Larger units used in some school kitchens can create sporadic interference problems with wireless networks operating on the 2.4GHz frequency and can be difficult to pinpoint due to the intermittent usage patterns.

High power radio transmitters such as Emergency Services radio masts in close proximity can ‘drown out’ wireless networks due to the high transmit power used even though they operate on different frequency ranges. High power electro-magnetic sources such as those found in some factories can also have the same effect as high power radio waves.

Planning & Configuring the Wireless System

Whether an un-managed or managed system is chosen, there are a number of design considerations that must be accounted for to ensure the wireless system will deliver reliable performance.

Channel Separation (Multi-Channel Architecture)

Wireless access points need to transmit on different non-overlapping channels for reliable operation. There are a number of channels available on the 2.4GHz and 5GHz frequencies providing this capability. The diagram Fig.2a below shows the 2.4GHz frequency range which provides a total of 13 channels although only 1 to 11 are currently used for Wi-Fi in the UK. To avoid interference and therefore provide reliable operation, each WAP needs to be configured to use channels 1, 6 & 11 only.

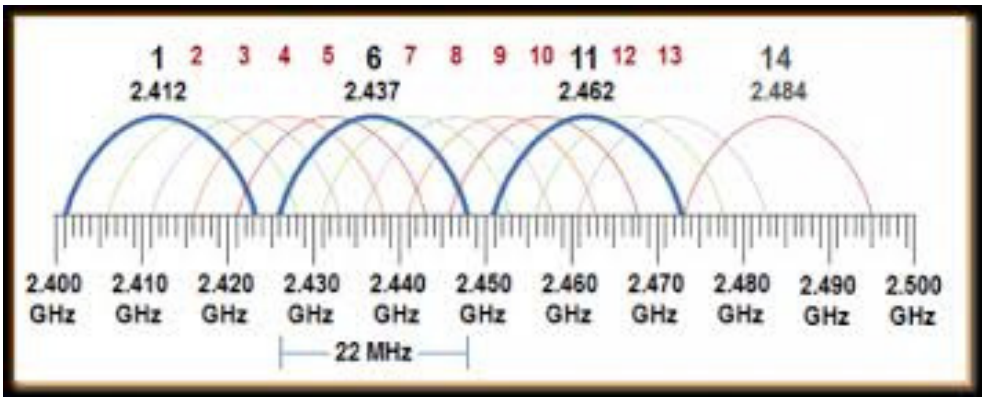

Fig.2a Non-overlapping 2.4GHz channels (1, 6 & 11) are shown in blue

The diagram Fig.2b below shows the 5GHz frequency range which provides a total of 16 20MHz non-overlapping channels currently used for Wi-Fi in the UK (36 to 64, 100 to 116 & 132 to 140).

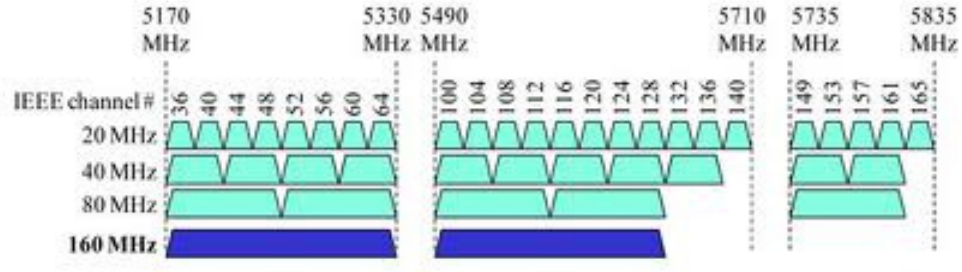

Fig.2b Non-overlapping 5GHz channels

Where multiple 2.4GHz WAP's are installed they will need to be configured so that each can only detect a maximum of 2 other WAP's on different channels e.g. for a WAP on channel 1, it should only detect two other WAP's on channels 6 & 11 respectively. If another WAP on channel 1 can be detected, interference will occur. The channel management on some 2.4GHz WAP's and on all 5GHz WAP's and managed systems is automated.

Wireless Coverage

Due to the nature of radio signals, the area of coverage is variable and depends upon the environment in which the wireless is installed. The ability to pass through objects will vary according to the construction of the building. Materials such as glass, plasterboard and fibreboard absorb little radio signal and therefore the area of coverage will be greater. Conversely materials such as brick, concrete and dense timber will absorb greater levels of radio signal and therefore coverage can be greatly reduced. The site plan below Fig.3 shows a simplified coverage map of a typical Primary School with existing WAP's indicated using standard channel numbers. The coloured areas indicate the expected signal strength from Green (High) through Amber (Medium) to Red (Low). Each WAP will be able to 'see' the others because they are detecting wireless signals where the coloured areas overlap.

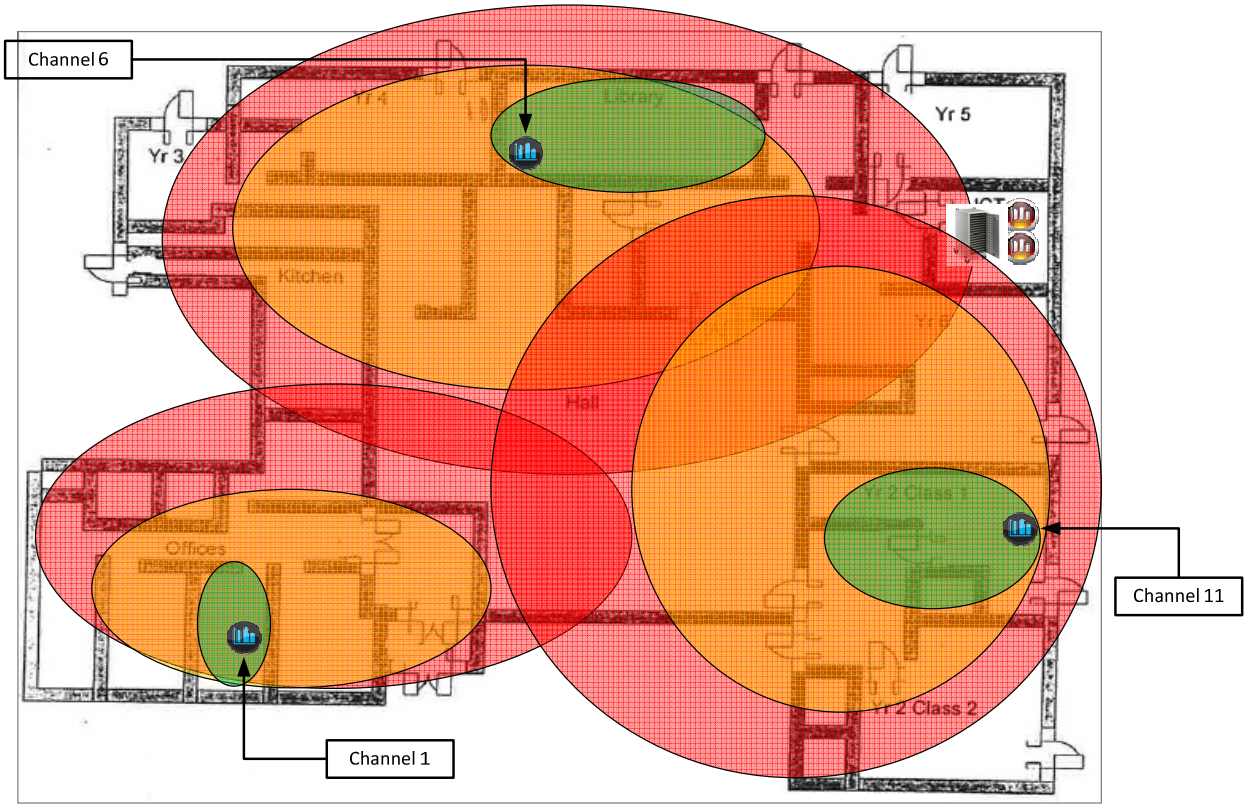

Fig.3 Primary School Site Coverage Plan

This configuration will prevent interference between the fixed points but in this example the school also has two additional WAP's fitted to the mobile Netbook trolley. Since there are only 3 non-overlapping channels available, whichever channels are configured on the two trolley WAP's will interfere with a fixed WAP at certain locations. As an example the trolley WAP's are configured on channels 1 & 11. If they are moved to Yr3 or Yr4 they will not interfere with the Library WAP on channel 6. If however they are moved to Yr6 one of the trolley WAP's will interfere with the Yr2 Class 1 WAP on channel 11. This will result in difficulty with connecting devices to the wireless and those that do connect may appear to operate very slowly.

Radio Channels & Transmit Power

As client density requirements increase the number of WAP's required also increases. Since there are a finite number of available channels this will inevitably result in channel overlap between WAP's. To prevent interference the transmit output power of the WAP's can be reduced. The default setting is full power which delivers signal strength of 20dbm. This can be reduced in 1dbm increments down to 1dbm. This enables the effective range of coverage to be reduced to prevent channel overlap without affecting data throughput performance. For large numbers of WAP's it is usual to reduce signal strength to contain the wireless coverage into a single room per WAP.

The site plan below Fig.4 shows the expected effect of reducing the transmit power on the three existing WAP's by 50%. This would allow the addition of further fixed WAP's. As an example we could now add another WAP in Yr5 set on channel 1 at 50% power without risk of interference from the WAP in the Head Teacher's office which also uses channel 1.

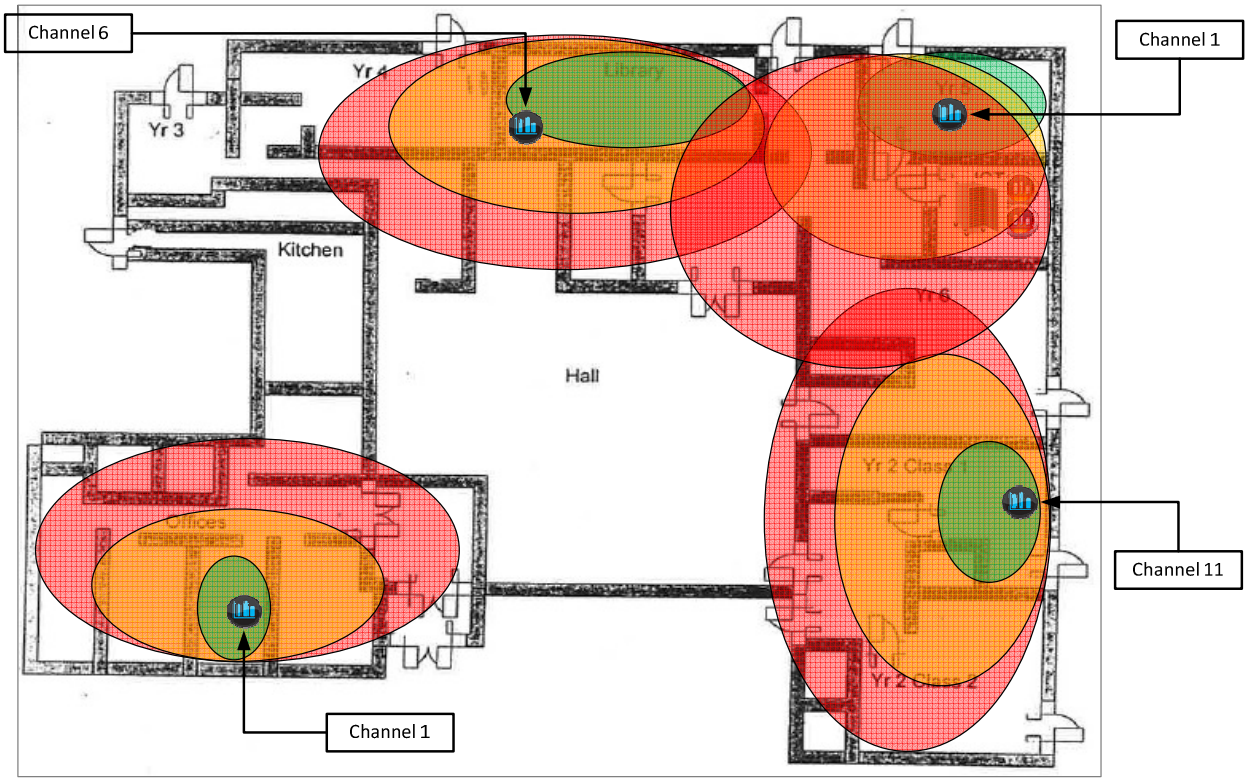

Fig.4 Primary School Reduced Site Coverage Plan

Although this simplified scenario does not take into account all factors that affect wireless performance, it does illustrate the difficulties that may be encountered and possible solutions to deliver a reliable wireless system to meet the needs of the school.

By following good design practice your school will benefit from a reliable and effective wireless network, enhancing the possibilities for teaching and learning and encouraging engagement with new more flexible technologies for staff and pupils alike.

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