QoS Parametric Correlation for Network Management, a Link between Application's Requests and Network's Capabilities

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Abstract: - Optimal resources management between application's requests and network's capability is determined by a human-device interaction, completing in this way the future architectural concept of developing inherent / integrated resource management capabilities inside the network elements. By aggregating and setting up QoS parametric dependencies between user's needs and network's context, resource management represents the guarantee for high performance network. Performing an analysis of application inter-frame delay and frame-size parameters – as the application's requested parameters – upon the received signal level, retries rate, channel throughput, and loss rate of the RF network – as the network's capabilities – the paper demonstrates that QoS parametric correlation can prove crucial on network resource management.

Key-Words: - QoS parameters, network management, frame-size, inter-frame delay, received signal level, retry rate, channel throughput, loss rate

1 Introduction

Deploying, implementing and controlling the parameters of a wireless networks is an elaborated task and even the smallest scenarios request for site survey, a challenging QoS (*Quality of Services*) resource management task inside the network.

Although considered obsolete by some, due to the new types of self-configuring / auto-negotiating / self-managing devices, the network management is far from that simply because a device, although able to analyze and communicate with its peers, can't understand the future application's needs, further resources and network possibilities [1], [2].

Optimal application's request vs. network's capability will be somehow determined by a human-device interaction, even the future internet concepts developed inherent management capabilities for the network devices.

In order to demonstrate that, the paper performs a site survey from a QoS resource management perspective in a WLAN (*Wireless Local Area Network*) particularly implementing the IEEE 802.11g standard recommendations.

Chapter 2 describes some particular and practical aspects on QoS parameters and network resources management, indicating the need for QoS parametric correlation.

Aggregating and setting up QoS parametric dependencies between user's needs and network's context – through a specific application QoS profile – resource management represents the guarantee for a high performance network services.

Chapter 3 introduces the concept of network site survey and its various forms, four alternative types for extracting the QoS network parameters.

Chapter 4 presents the design and correlation process of the RF (*Radio Frequency*) QoS network parameters in order to meet the application's requests.

There is performed an analysis of application inter-frame delay and frame-size parameters – as the application's requested parameters – upon the received signal level, retries rate, channel throughput, and loss rate of the RF network – as the network's capabilities.

Pre-build theoretical surveys and post-build adjustment surveys were realized by using *AirMagnet Survey* and *AirMagnet Laptop Analyzer*, licensed industry-grade software tools. Scenario configuration and detailed results analysis is presented.

Chapter 5 of the paper highlights some relevant conclusions invocating the QoS parametric correlation need for a reliable managed network.

2 QoS Parameters and Network Resource Management

Considering the multitude of traffic types vehicle in network segments (video on demand, voice over IP, IPTV, video conference, file transfer etc.), there are a number of QoS parameters that influences, determines and affects the application's performances [3], hence the quality of the expected services' level in the network.

2.1 Quality of Services

There is little consensus on the precise definition of QoS. Researcher groups perceive and interpret QoS term in different ways [4] [5]. In order to group this point of views and to illustrate ITU, ETSI, and IETF perspectives, a general QoS model presented in [6].

There are associated three notions of QoS approach, defined in the general model:

- intrinsic QoS;
- perceived QoS;
- assessed QoS.

Intrinsic QoS is determined by the transport network type and provisioning of network access. Perceived QoS reflects user's experience of using a particular service and user's expectations compared to observed service performance. The assessed QoS starts to be seen when the customer decides whether to continue using the service or not.

The ITU and ETSI perspectives to QoS related terminology are almost the same. Both organizations adopted the same definition of QoS concept, described first in [7] as "*the collective effect of service performance which determine the degree of satisfaction of a user of the service*". QoS in the ITU/ETSI vision adheres mainly to perceived QoS rather than intrinsic QoS. IETF focuses on intrinsic QoS and does not deal with perceived QoS. QoS is understood by IETF as "*a set of service requirements to be met by the network while transporting a flow*" [8].

Analyzing the source that generates these factors and analyzing their effects, we understand that QoS problem has two distinctive issues:

- the network / infrastructure perspective evaluated through an objective analysis;
- the service / application point of view generated by a subjective perception.

From the network / infrastructure perspective, QoS refers to the service quality or service level that the network offers to applications or users in terms of network QoS parameters, including: delay, jitter, reliability of packet transmission, and channel throughput.

From the service / application perspective QoS generally refers to the application quality as perceived by the client. That is, the presentation quality of the video, the responsiveness of interactive voice, and the sound quality of streaming audio.

2.2 QoS Parameters

Different traffic types have different requests for resources to be allocated in the network segments, requirements expressed in terms of the QoS parameters.

The following parameters are relevant when evaluate an application:

- throughput or channel capacity (BW);
- transmission delay or latency (Delay);
- delay variation (Jitter);
- loss or packet error rate (BER).

Table 1 illustrates some examples of different application's request, in a wireless system, expressed in terms of QoS parameters.

Application type	BW (kb/s)	Delay (ms)	Jitter (ms)	BER
Broadcast/ Multicast	$1\text{-}10^4$	<2000	<500	$<10^{-8}$
VoD	$1\text{-}10^4$	<2000	<500	$<10^{-7}$
VoIP	10-50	<50	<10	$<10^{-6}$
Video conference	$100\text{-}2\cdot10^3$	<150	<50	$<10^{-7}$
Web traffic	50-500	<500	<250	$<10^{-7}$
File transfer	50-500	<500	<250	$<10^{-6}$
FTP	50-500	<500	<250	$<10^{-7}$

Table 1. Different application's requests needed to be accommodated in a wireless network

The network resources need to be distributed to all applications in a way that simultaneously satisfies all QoS requirements [9].

It is up to the application to request for resources in the network, but it is up to the network to know better its capabilities. Therefore, in order to better satisfy the application's requests for resources in the network, the resource management system should include application semantics description through the QoS parameters and this is a very challenging task.

2.3 Network Resource Management

It is a real debated issue whether QoS network management is needed or no.

One opinion is that the transmission medium will make bandwidth so abundant and cheap that QoS support will be automatically delivered. The other opinion is that no matter how much bandwidth the networks can provide, new applications will be designed to consume them; therefore, resource management will still be needed to provide QoS support [10].

Recent applications are associated with user interactions, and the ability to browse different scenarios at the same time. All these aspects made the researchers look for other solutions in order to assure a network resource management [11].

A first approach on provisioning support of resources placed the QoS mechanism on the end-system, including (1) source rate control, (2) transfer rate adaptation, (3) packet error control, and (4) retransmission [12] [13]. Many of these mechanisms, from a QoS intrinsic perspective, can be categorized as adaptive applications [14].

Another approach on provisioning management of resources is to provide in the network a mechanism based on QoS parameters monitoring and correlation. In this approach, the network node plays an active role in controlling and reporting to the upper layers the end-to-end service quality. This requires additional traffic control mechanisms to be introduced, such as (1) admission control, (2) traffic policing, (3) classification, and (4) traffic scheduling.

IETF has proposed several service models and mechanisms to meet the demand for QoS. As the QoS parameters are determined and influenced by each other, there must be identified a correlation function, or link between application's requests and network's capabilities.

In other words, in order to control the resources of the network, the QoS resource management must correlate the application's QoS requested parameters to the network context or capabilities.

The paper emphasizes the need for a thorough site survey, both application perspective and network point of view, prior to wireless network deployment in the area to be covered.

Correlating QoS parameters trough a link between application's requests and network's capabilities, a more efficient QoS network resources management is obtain.

In this context, performing theoretical, assisted, and manual network site survey, the paper studies the influence of the application frame size and inter-frame delay variation, on received signal level, retries rate, channel throughput, and loss rate as network parameters.

These QoS parametric evaluations can prove crucial when setting up a transmitter and can make the difference between a working and a faulty network.

3 Network Site Survey

Implementing a new WLAN is an elaborated task and even the smallest scenarios request for resource management through the network site survey.

The consistence of a network site survey is a problem that is more and more present in the minds of troubled wireless network administrators and, as speeds go up, so does the need for higher network capacity or coverage, increase SNRs (*Signal-to-Noise Ratios*) and reduce SIRs (*Signal-to-Interference Ratios*) in order to support the necessary modulations transmitting the all-so-valuable bytes.

This is why, prior to network installation, RF (*Radio Frequency*) network management that performs the survey must ask some preliminary questions on the following:

- how can the physical and RF environments cope with the new wireless equipment;
- which are the needs of the organizations where the wireless network is to be placed;
- what is the site survey location and sources of interference;
- which are the coverage requirements and application's constrains;
- which are wired network characteristics that is going to integrate the wireless equipment needed;
- which are the applications characteristics and corresponding network's parameter configuration in order to deliver the requested services by the user.

3.1 Aspects of Site Surveying

While it is more important to implement a WLAN that meets the beneficiary's needs than just merely placing transmitters, the network site survey must be well documented by listing the requirements and the expectancies of both the users and the network infrastructure. In this case, the first step is the requirement analysis for resources.

The requirement analysis for resources must correlate the user request for services (voice traffic, multimedia application, ftp transfer etc.) with the network's parameters (transmission range, channel capacity, propagation losses, antenna gain etc). In a wireless network, cell size could differ inside the coverage area according to the user constrains. All these indicate that a specific service request for a specific network context.

Further, the network site survey analysis has to move on to investigating the potential environment context. Business requirements – generally these are the most hard to meet – and functional requirements – handles problems like roaming or quality of services aspects – have to be discussed in parallel to underlining budgetary, technical and regulatory constraints [15].

In the mean time, the nature of the present core network must be well understood and emphasized to the customer as well as the realistic expectations for the future wirleless network. The quality of wireless access network it is strongly correlated with the quality of the wired network. That is why the site surveyor had to investigate if the selected equipment can yield the needed results.

Concluding, the pre-site survey form along with the collected information on network and users should provide a good image of the needs and possibilities.

3.2 Types of Network Site Survey

Network site survey must supply enough information to accurately locate, install, and configure the RF parameters of the APs (*Access Points*) transmitters and antennas, which will have to provide the required coverage and performance defined in the wireless network design [16].

Introducing site survey for wireless network design and resource management, the idea focuses on one of the four basic types: manual, automated, assisted and theoretical. Each of these has some specific goal and, quite naturally its pros and cons.

3.2.1 Manual Site Survey

This is the main and most thorough method and it requires physically being at the location and taking actual RF signal level measurements throughout the site.

Walkabouts on logical paths throughout the site are performed right after having initially placed an AP with an attached transmitting antenna. This is obviously the most accurate method, apart from requiring a lot of RF signal propagation knowledge [15], [16].

In the mean time it is the most time consuming but it can be performed with laptops or handhelds running specialized for spectral analysis.

3.2.2 Automated Site Survey

Attempting to make wireless networks installation easier – and more accessible to the RF – the automated site survey promotes the idea of placing an AP on the site based strictly on the location and density of users and having it self-configured and self-managed [16].

This is a tricky method as it can lead to redundant APs being placed – resulting in excessive cost – or poor coverage in case of AP deficit. In the mean time, not all the RF path to the destination could be modeled, consequently interference and channel access retries occurs.

3.2.3 Assisted Site Survey

Assisted site survey is basically consists in a mix of totally manual and totally automated surveys, considering only the advantages from each of the aforementioned. Still, some manual surveying and minimal RF considerations about antennas and propagation is required for the initial design. However this survey type is not always suitable as it can lead to poor RF coverage, or increase inexplicably the cost of the survey and gear to be bought [16].

The idea is to take manual measurements in selected areas and then, logically extrapolate the results for the rest of the site under survey. Finally a walkabout is done alongside a client that will use the wireless network to be deployed. The obtained data on overall link performance is passed to the configuration system that makes the final adjustments in the APs configuration.

3.2.4 Theoretical Site Survey

In order to avoid time consuming walkabout surveys, tools that provide theoretical RF coverage plans for wireless network have been developed.

To use a theoretical tool, input such as an aerial photo or scaled or scanned blueprints of the site is required instead of the physical on site activity. Descriptions of the construction and contents as well as the attenuation factors entered into the system are required [16].

Propagation models, types of antennas and transmitter location further to be used into the program are also input and the system will determine theoretical RF patterns to be used in the site. A graphical representation of the coverage and capacity can be viewed and analyzed. Tools that perform such analysis are quite accurate, but very expensive. It is good to remember that the results are only estimations.

4 Site Survey and Network Performance Analysis

The present paper emphasizes the need for a thorough network site survey, both network and application perspective, prior to WLAN deployment in the area to be covered.

Coverage and performance include some minimum network value at all defined user locations and requests application constraints for services delivery.

In the mean time, a network site survey should include a report detailing other interference or competing RF signals.

Recommendation for proper placement, mounting, and configuration of APs and antennas to mitigate these competing RF signals is another requirement of the network site survey.

4.1 Site Survey Tools

In order to analyze the influence of inter-frame delay and frame-size application's parameters upon the received signal level, retries rate, channel throughput, and loss rate network's parameters, pre-build theoretical surveys and post-build adjustment were performed by using license *AirMagnet Survey* [17] and *AirMagnet Laptop Analyzer* [18] tools.

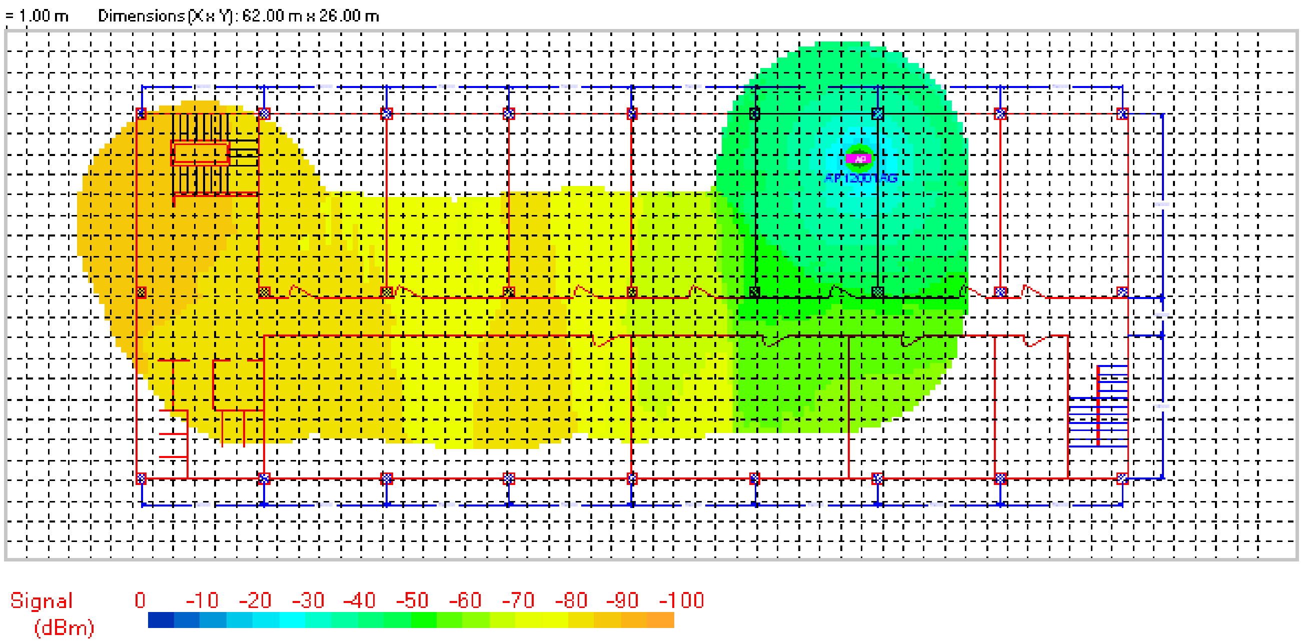

Fig. 1 Passive coverage area for the tested area

AirMagnet mainly supplies two modes for collecting survey data:

- passive mode;
- active mode.

Passive mode allows the access client to measures the RSSI (*Received Signal Strength Indicator*) level of the radios sent by the AP in the network.

This mode is mostly useful for post-install operations, measuring parameters like signal levels, SNR, interference levels and frame delays. Fig. 1 presents the signal level distribution in case of a passive coverage mode. Active mode allows the access client to associate to an AP and send round-trip data packets.

This is the closest simulation to a real wireless network environment, making it appropriate for initial AP surveys and alongside the planner a vital tool for pre-install operations.

The active operation mode offers parameters like signal strength, channel capacity and SNR when a station connects to a specific AP or a predefined SSID (*Service Set IDentifier*).

For this mode, the client associates to the most suitable AP detected by the integrated sniffer while roaming through the scenario facility.

The status panel always displays the SSID and MAC (*Medium Access Control*) as identifiers of the attached AP.

4.2 Analyzed QoS Parameters

The paper analyses the frame size and the inter-frame delay as QoS requested parameters by the application.

The application frame size through the RF environment can be controlled by the fragmentation threshold.

The inter-frame delay is set by the application layer and is actually the transmission rate for new frames that are going to receive lower network layer overheads and transmitted through the channel.

4.3 Test Scenario Description

The test scenario consists of wireless *Cisco AIR-CB21AG* clients linked to *Cisco Aironet 1200 Series* access points. The APs are equipped with a Cisco Aironet 5.2-dBi omnidirectional ceiling mount antenna – *AIR-ANT1728* – and a Cisco Aironet 14-dBi vertically polarized sector antenna – *AIR-ANT2414S-R*. The facility blueprint of the area, indicated by Fig. 2, presents the location of the APs. Sector antenna is attached to the AP1 (x=34.9 m, y=2.25 m), while omnidirectional antenna is attached to AP2 (x=25.8 m, y=16 m).

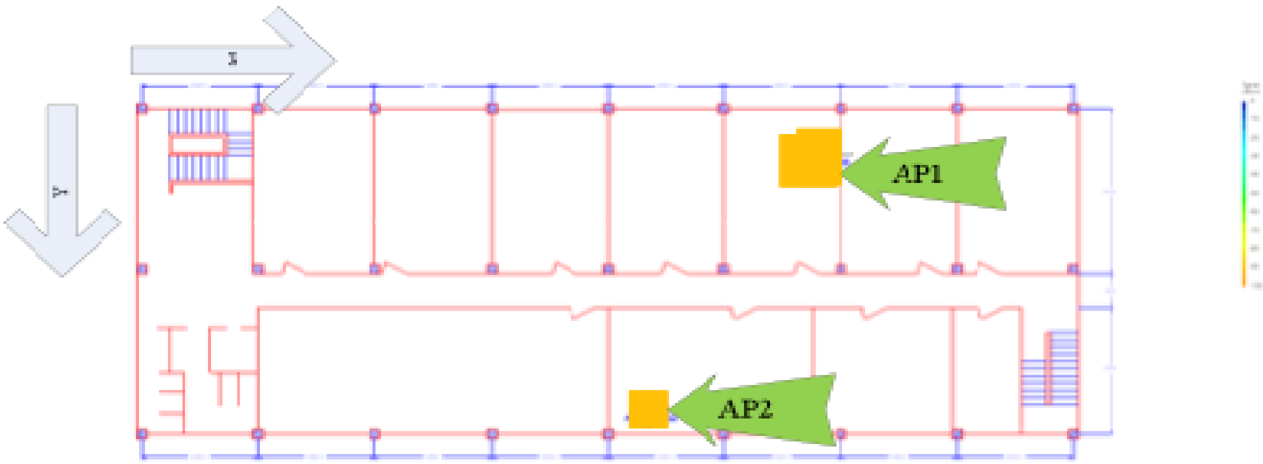

Fig. 2 APs placements within the premises

There are defined five measurements points of analysis used to evaluate the QoS application's requests with network performance for each network site survey type, as presented in Fig. 3.

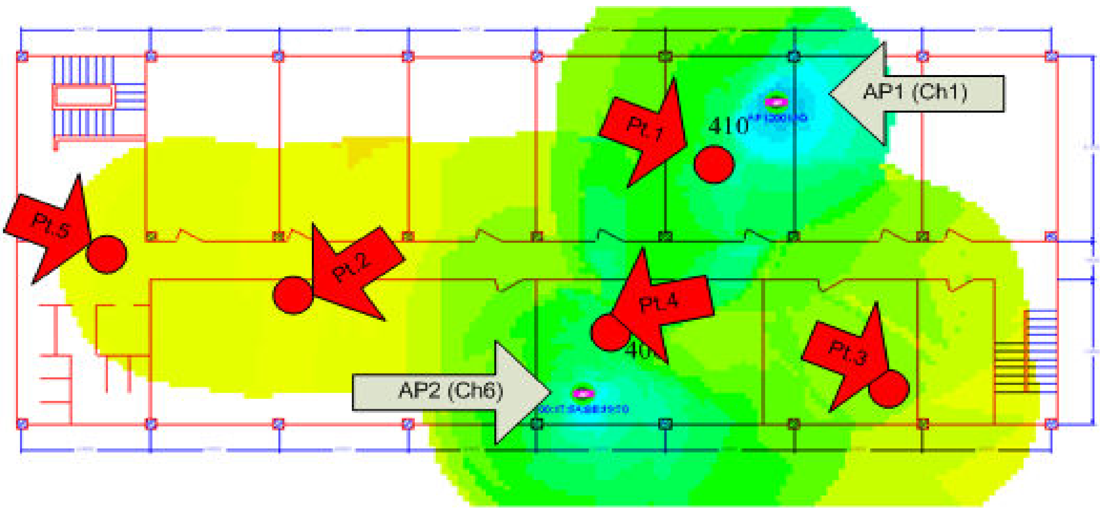

Fig. 3 Analysis / measurement points

Performing theoretical, assisted and manual network site survey by using dedicated presented software tools facilities, the paper studies the influence of frame size and inter-frame delay variation for a wireless network implementing IEEE 802.11g standard recommendations.

4.3.1 Theoretical Network Site Survey

Theoretical site survey corresponds to a passive survey mode, illustrating the signal level distribution over the analyzed environment.

According with the application requests, one could indicate correspondent service area based on signal distribution over the tested area.

As previously mentioned, theoretical survey can be faster but involves simulation of the radios propagated in the area and a prior estimation of the attenuations.

Fig. 4 shows the yielded results after connecting the two antennas (H/E patterns, orientation), placing the AP1 and AP2 and associating each element losses.

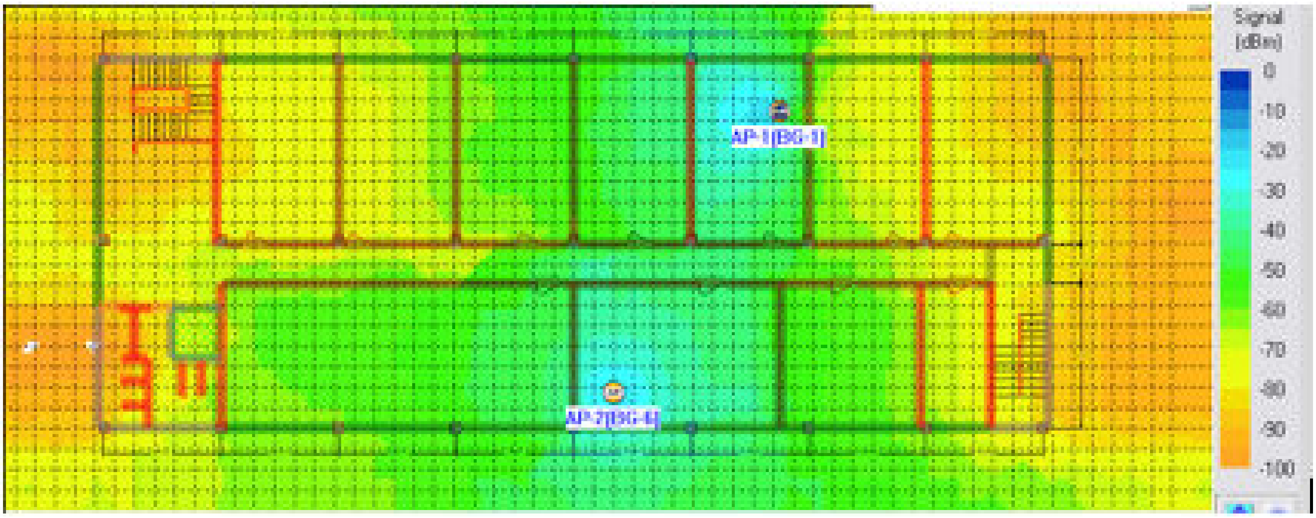

Fig. 4 Theoretical Network Survey Results

Working with theoretical network surveys, we start by estimating the attenuation introduced by each type materials present at the location.

We obtain these values after measuring the RSSI on the site closest to the AP and subtracting the value of the RSSI on the other side of the obstacle.

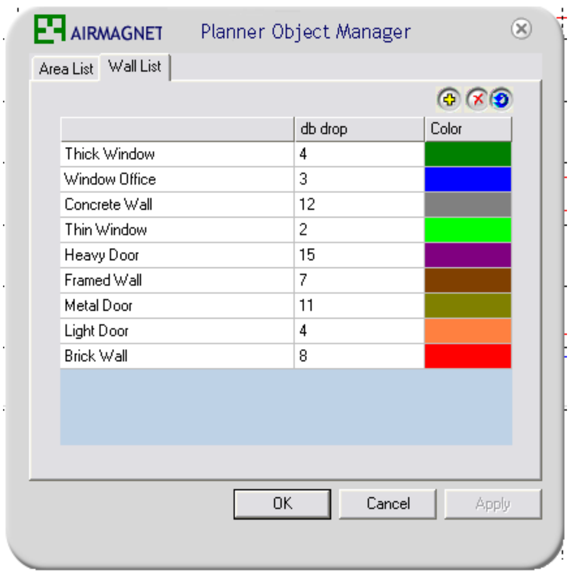

Fig. 5 The planner object manager and building materials considers by theoretical network site survey

The planner object manager interface offers the possibility to associate the measurements to the corresponding components of the floor plan, as illustrated by Fig. 5.

4.3.2 Assisted Network Site Survey

Assisted network site survey corresponds to an active survey mode for collecting data. Based on a direct interaction with the environment, the site survey offers the possibility to estimate specific application behaviors sweeping the, packet size and inter-frame delay QoS parameters.

Assisted network survey was realized by selecting different values for the transmitted packet sizes and associated inter-frame application delay.

Further, assisted survey offers the possibility to get the coverage area assigned to a specific service level. Using *Cisco AIR-CB21AG* clients, a minimum of -71dBm received signal level at the receiver indicates a 54Mbps data delivery. This could be viewed as a requested QoS parameter for voice or real-time multimedia transmission. Starting the walkabouts for each of the twenty possible types of modeled application and considering a user application request for -71dBm, as a minimum requested signal level at the receiver, assisted survey offers the coverage illustrated by Fig. 6.

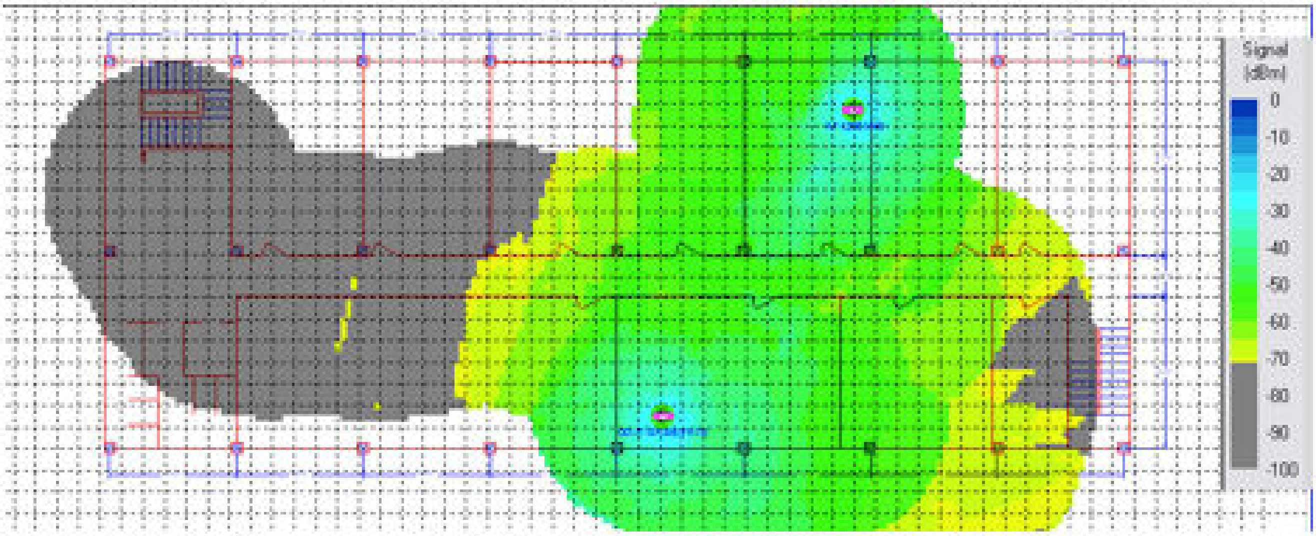

Fig. 6 Assisted Network Survey Results

The benefits of assisted network site survey are that it brings some user information based on application characteristics and indicates the contour of the service area only for the minimum requested signal level of -71 dBm.

In this way, assisted network site survey performs QoS parametric correlation between the application's request, and the network's capabilities, as automated resource management.

4.3.3 Manual Network Site Survey

Compare to the theoretical and assisted site surveys, manual site survey took the longest and yielded the most accurate results.

Completing the benefits of previous analysis, manual network survey allows the setting of QoS application's parameters: test period, fragmentation threshold, transmission rate and maximum number of allowed retries.

We set up the test period to 15s, the frame size to 128B, 256B, 512B and 1024B while sweeping the inter-frame delay successively to 10ms, 50ms, 100ms, 250ms and 1000ms.

Performing the manual network survey, we analyze the following QoS network's parameters:

- the signal level at the receiver - Fig. 7;
- the percentage of the retry rate per transmitted packet size - Fig. 8;
- the influence of packet size on data throughput - Fig. 9;
- the percentage of loss rate at the analysis point (Fig. 10) for the first point of measurements.

Analyzing results, received signal level constraint indicates in Fig. 7 that it is appropriate to attach the station to AP1 transmitter, although it could be attached in some cases to AP2 too.

Therefore, in this case only the next QoS parametric analysis will help us to take the best decision.

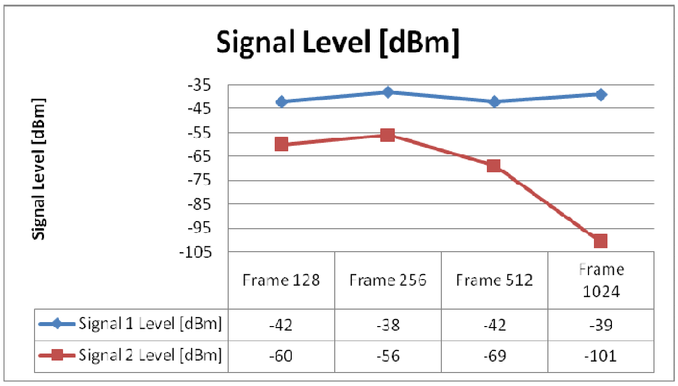

Fig. 7 Signal level at the receiver and corresponding transmitter site

Analyzing the retry rate percentage per transmitted packet size indicated by Fig. 8, we observe that the packets occurs a high transmission retry rate in case of AP2.

This aspect is always caused by a multi-path propagation, a busy channel or a high level of interference at the measurement point.

Correlating the received signal level and the retry rate percentage, we could now firmly indicate AP1 as the most appropriate transmitter from the transmitter's measurements point of view.

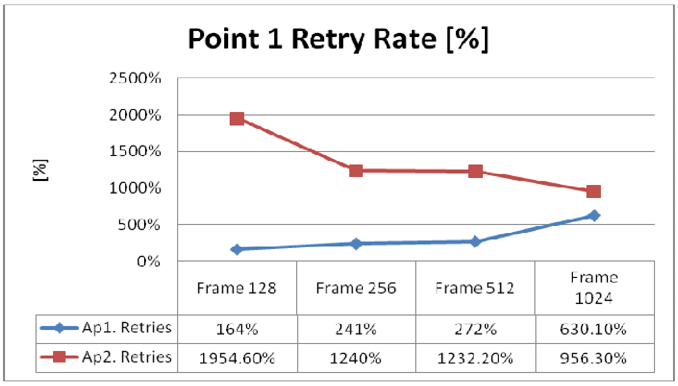

Fig. 8 Retry rate per transmitted packet size

A parallel analysis of data throughput over the retry rate percentage reveals the cost for larger fragments size presented in Fig. 9 – a busy channel mostly charge with control information and access transmission requests. Despite of that, one could assume a higher retry rate for a higher data rate.

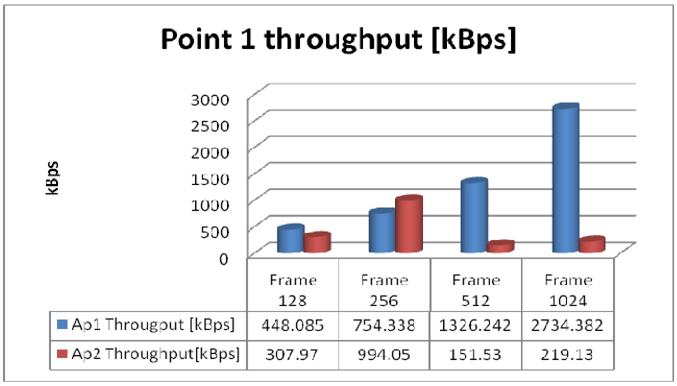

Fig. 9 Influence of frame size on data rate

Results analysis of loss rate percentage presented in Fig. 10 indicate the best fragment size as 256B and reconfirm the AP1 transmitting site selection.

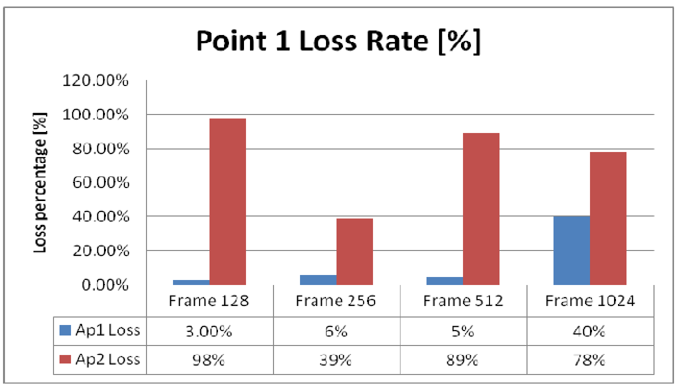

Fig. 10 Loss rate and corresponding frame sizes

In the mean time, according to our initial imposed requirements, we could affirm that AP1 is the selected transmitting site and a 256B packet is the most appropriate fragment size for our scenario.

Traffic QoS parameter analysis – based on signal measurements at the receiver, percentage of the retry rate per transmitted packet size, influence of packet size on data rate, and percentage of loss rate at the analysis point – reveals that resource management must be performed not only form the network perspective, but from the application point of view too.

Used network survey analyzing tool permits the variation of transmitting inter-frame delay as the QoS application parameter, as presented in Fig. 11.

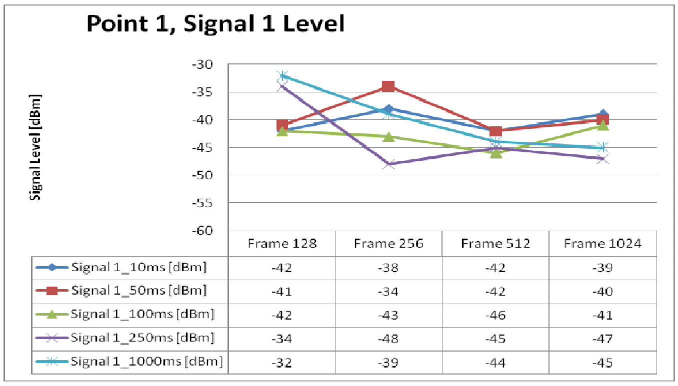

Fig. 11 Inter-frame application transmitting delay

QoS parametric analysis reveals that the application's performances are independent with the inter-frame transmission delay.

Consequently, the critical problems in our scenario are the sources of interference and multipath propagation reflected by a high retry rate and loss rate.

5 Conclusion

Although considered obsolete by some, due to the new types of self-configuring / auto-negotiating / self-managing devices, the network management is far from that, simply because a device, although able to analyze and communicate with its peers can't understand the future user's needs and further network possibilities, in terms of allocating network's resources and considering application's requests

In this context, the paper emphasizes the need for a thorough QoS resource management, both application perspective and network point of view, prior to wireless network deployment in the area to be covered.

Performing theoretical assisted and manual network site surveys, the paper studies the influence of the application frame size and inter-frame delay variation – as the application's QoS requested parameters – on received signal level, retries rate, channel throughput, and loss rate as network parameters – as the network's capabilities.

Measured and analyzed parameters confirms the need for QoS parametric correlation between the application requests and network capabilities, while a manual site survey offers the most appropriate network resource management scenario.

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