Advantages of Concurrent, Multi-Channel WiFi3™

Edgewater Wireless' innovative and revolutionary chipset enables true multi-channel WiFi.

WiFi3TM is backed by 24 patents to deliver multiple, concurrent channels of transmit and receive on the same radio. With 3 channels in 2.4GHz and up to 9 Channels in 5GHz. Edgewater Wireless technology multiplies the bandwidth available by utilizing multiple channels simultaneously – creating an unprecedented range of control across the RF spectrum.

Architecture

Edgewater Wireless' WLAN chipset – WiFi3TM is a new generation of RF and analog front ends with very high dynamic range, linearity, low noise and sophisticated, integrated digital baseband processing.

The chipset is controlled via multithreading software MAC running on an integrated RISC core which may be bypassed in parts or in its entirety for custom MAC implementations. Edgewater Wireless provides several key hardware hooks within its RF; analog and digital front ends to give customers full access to the complete wireless spectrum, which it makes available to them for the first time. This empowers access point designers to implement proprietary software that will control the wireless environment and AP deployment to an unprecedented degree. Ranging from single AP networks to large campus style enterprise deployment.

The concept of wideband spectrum conversion is shown in Figure 1, with reference to the 2.4GHz ISM band (used in 802.11b and 802.11g WLAN systems). Currently, 3 channels of 802.11b may be present at one time in this band. Existing WLAN chipsets are capable of operating on one of these channels at any given time. The 802.11b protocol sets up a half duplex communication on any 14 available channels (width approximately 22MHz). However, channels 1, 6 and 11 are allocated in non-overlapping frequencies as shown in Figure 1.

FIG 1: Wideband 802.11b Wireless LAN Operation

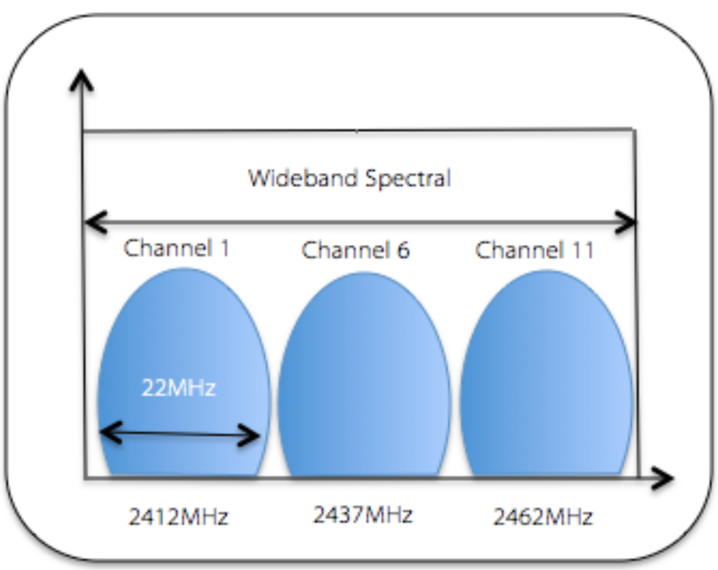
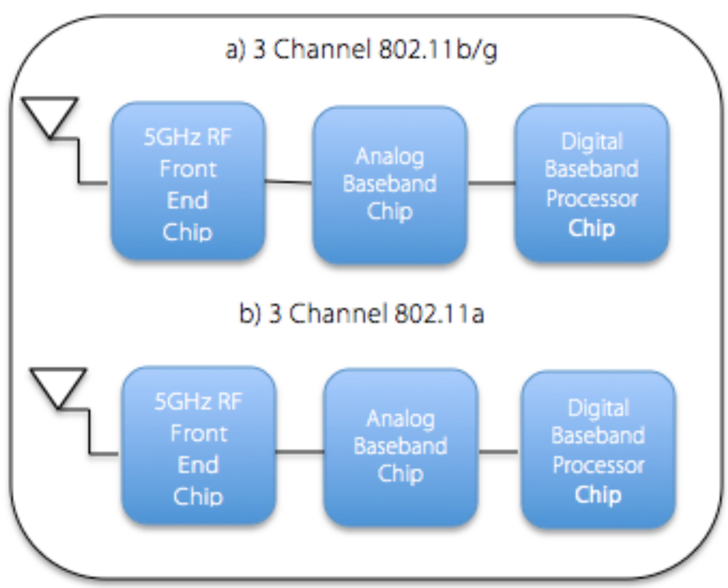


FIG 2: Three Channel 802.11 Architecture



Architecture

These channels could be received and transmitted simultaneously if the chipset allowed for capturing all 80MHz (in the United States) in the 2.4GHz band. What would be required are a bidirectional full duplex RF and analog front end and a digital baseband capable of channelizing the data stream into individual blocks of spectrum and processing the resulting streams. This functionality is present for the first time in Edgewater Wireless' wideband WLAN chipset. It can process three channels of 802.11b as in this example, for a maximum throughput of 3 x 11Mbps=33 Mbps, or three 802.11g channels or 802.11a channels for a maximum throughput of 3 x 54= 162Mbps. The chipset may be scaled to enable systems with 6, 9 or more simultaneous 802.11a/b/g channels in a straightforward fashion.

Figure 2 shows the simplest implementations of Edgewater Wireless' WLAN wideband chipset. The chipset is composed of 3 component chips: an RF front end chip specific to the 2.4GHz or 5GHz bands, an analog baseband chip and a digital baseband processing chip incorporating a full MAC engine for running MACs such as Edgewater Wireless' 802.11 software MAC. The RF chips and analog baseband chip incorporate unique Edgewater Wireless IP to achieve unprecedented linearity, noise figure and dynamic range and thus enable true wideband operation. A high degree of isolation is present between the transmit and receive paths to enable full duplex multiple channel communications, i.e. the ability to transmit on 1 or 2 channels and receive on the other 1 or 2 channels at the same time.

The digital baseband processor channelizes and modulates/demodulates all the channels simultaneously and provides several new features to take advantage of the wideband nature of the front end. Some of these features are implemented in low level hardware and software blocks specifically designed to obtain the best possible performance in multiple channel environments, such as unique wide band automatic gain control to optimally receive multiple incoming channels simultaneously.

Others take the form of programmable elements, which may be controlled by higher level and spectral monitoring hardware modules. In particular, a wideband FFT module is present in Edgewater Wireless' digital baseband processing chip and is capable of processing the entire 180MS/s output stream from the analog chip to provide real-time (microsecond increments) high resolution snapshot of all 80MHz of spectrum for passing to higher software layers.

Architecture

These elements and features enable the creation of new software algorithms to automatically detect other communications and RF energy in the ISM bands, and to effect differentiating wireless performance such as automatic WLAN deployment, robustness, maintenance, and upgradability. From the raw performance perspective, the three channel architectures shown in Figure 2 immediately enable access points (APs) to have a maximum throughput of 33 Mbps when all three channels are 802.11b, or 162 Mbps for three channels of 802.11g or 802.11a. The 2.4GHz architecture of Figure 2(a) can also handle one or two channels of 802.11b and two or one channels of 802.11g simultaneously, allowing for gradual upgrading of the client base, without requiring further change in AP infrastructure.

The system shown in Figure 3 enables the use of three simultaneous 802.11b/g channels over the 2.4GHz path composed of the upper three chips, and the use of three simultaneous 802.11a channels over the 5GHz path composed of the lower three chips.

The 5GHz RF front end may be tuned to different parts of the available spectrum in the 5GHz band, since the total bandwidth available is wider than the 80MHz bandwidth of the front end and analog baseband chip. It is also possible to construct simultaneous six channel systems using six chips as in Figure 3, except that both front ends are 5GHz front ends if 2.4GHz operation is not required. Finally, a nine channel simultaneous 802.11 a/b/g system may be constructed from nine chips in the configuration shown in Figure 4.

The dynamic range of Edgewater Wireless' analog front end enables the simultaneous reception of multiple channels at widely differing power levels, simultaneous transmission of multiple channels at widely differing power levels, and simultaneous transmission and reception on separate channels in the same band. MAC level functionality further enhances this low level performance by intelligently controlling transmit power to different users according to their perceived distance (signal strength at the AP), and assignment of users to the optimal channel for maximizing throughput.

FIG 3: 6 Channel Dual Band Architecture

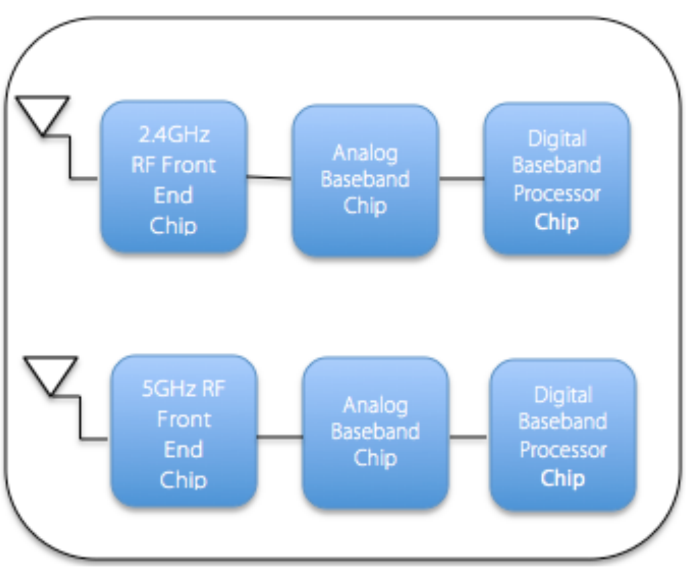
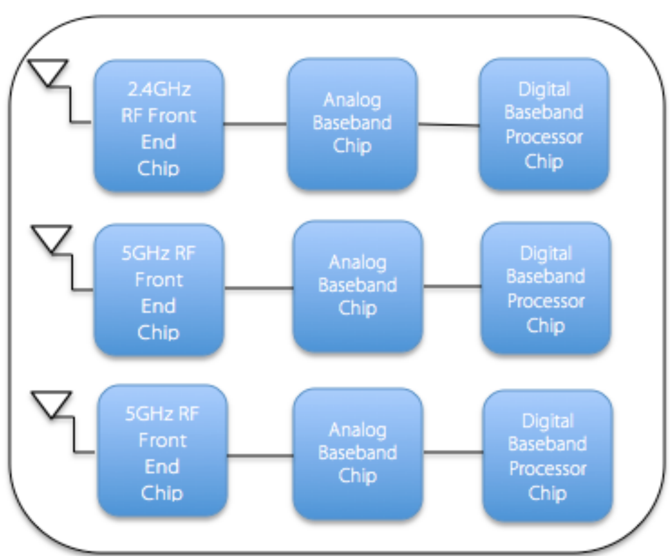


FIG 4: 9 Channel Dual Band Architecture



Architecture

These techniques intelligently manage side lobes and interference which arise from non-linearity's in the transmit and receive paths, particularly the power amplifiers of the clients and the APs themselves. Such techniques incorporating all information on the total spectrum available in Edgewater Wireless' single WLAN chipset solution are necessary for good multiple channel performance. Performance would be unacceptably poor if an attempt is made to construct multiple channel solutions from co-located previous generation single channel front ends and basebands.

As a result, previous generation solutions are essentially limited to a single channel within each AP radius, which has to be shared among several users. The Edgewater Wireless WLAN wideband chipset allows up to 15 times the number of channels visible to each user in such a situation, thereby providing a user experience meeting or exceeding that of high speed Ethernet wired solutions.

Edgewater Wireless' wideband WLAN chipset is a true spectrum processor. The most obvious benefit of using Edgewater Wireless' wide band WLAN chipset over existing previous generation single channel solutions is the raw bandwidth improvement of a three-channel radio which performs up to 50 times greater than that of a single channel 54 Mbps 802.11a or 802.11g radio. Using the controls provided for in the Edgewater Wireless chipset, and the spectrum monitoring information fed back from it, a vast array of powerful new services in addition to raw increased bandwidth can be provided. This section examines some new applications it enables. Implementing some or all of these applications brings a new powerful class of easy-to-operate and robust wireless networks into being.

Quality of Service

Quality of Service

Multiple channel availability in each AP allows for a much higher quality of service than current generation APs, which only offer one or two channels. The availability of multiple channels from a single AP will naturally improve the user experience by the number of channels distributed over the users present. In addition, each AP may be programmed by IT managers to customize the service given to particular clients. High bandwidth/high priority clients may be given (a) dedicated channel(s), for example, to maximize the bandwidth available to them at the physical layer. Groups of clients may be treated in the same way. Edgewater's spectral monitoring FFT block may also be used to dynamically pick out the quietest portions of the available spectrum without interrupting existing transmissions. Critical transmissions may then be actively relocated to quieter spectrum.

Intelligent Channel Association

By intelligently associating clients to strategic channels based on signal integrity, 802.11 standard, traffic type, and traffic load, huge gains in WLAN performance can be realized. For example, the throughput of a single channel 802.11b/g AP servicing a number of clients associated at different data rates will be limited by clients associated at the lowest data rates. Because clients associated at high data rates have to wait for access to the medium while slower users communicate, aggregate AP performance is negatively impacted, resulting in reduced performance for all users. Edgewater Wireless technology allows a multi-channel AP to dedicate certain channels to slower clients such as 802.11b clients or those far away from the AP; thereby reserving other channels to users associated at higher data rates. The result is a performance improvement of up to 15 times or greater depending upon client mix and network configuration.

Additionally, demanding traffic types such as Voice over Wireless Internet Protocol (VoWIP) can be intelligently assigned to dedicated channels to ensure the level of guaranteed service that isochronous traffic requires.

PowerZoning

Edgewater Wireless' wideband WLAN chipset enabled APs can be set to transmit on different power levels seamlessly by virtue of having a high dynamic range on their transmit as well as receive paths. In particular, this enables setup of multiple APs in a frequency reuse situation so as to minimize interference between APs. This is critical since solving the AP interference problem greatly enhances the enterprise experience in large flat building topologies/campuses, and allows APs to be more densely packed (improving capacity further). A power zoning arrangement for the example of six channel APs is shown in Figure 5. In the example shown above the APs are programmed so as to transmit on full power for only a couple of channels, but to transmit on reduced power for all other channels available. Users within the inner transmit power ring around all APs get the benefit of four full channels' capacity; reduced capacity is offered to the other users in the outer ring so as to minimize interference with adjoining APs.

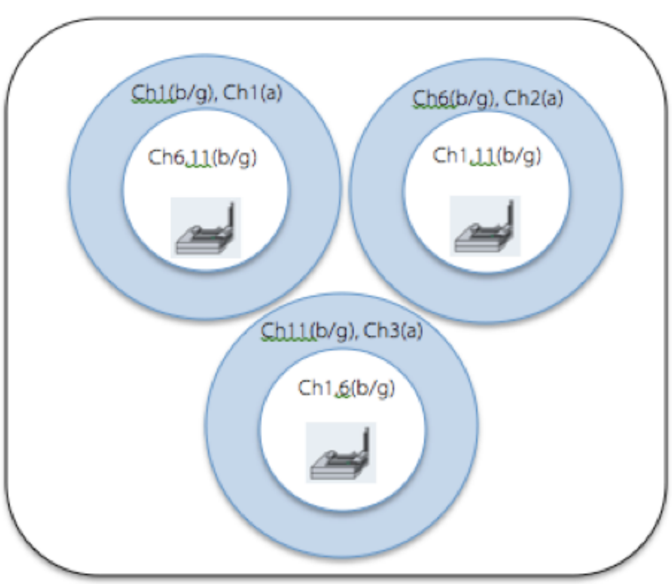
Automatic AP deployment removes the need for manual RF deployment of large campus/office building AP networks and is key to the future of wireless LANs. Edgewater Wireless enables true automatic AP deployment for the first time with the features of its wideband WLAN chipset. This removes the need for any intuition or measurement of the RF environment on the part of system administrators and makes wireless networks as straightforward to install as wired ones.

PowerZoning Cont'd

Full spectral monitoring using the Edgewater Wireless chipset's FFT wideband monitoring module and wideband three channel simultaneous demodulation paths is the key to automatic AP deployment. With each AP effectively able to take full spectral snapshots on a microsecond basis and pass this data up to higher layers, it is easy to program APs to detect each other and set transmit powers/channels accordingly so as to minimize interference. An example of automatic AP deployment is shown in Figure 6.

In this figure, a new incoming AP is being added to an existing network and is programmed to listen in wideband mode before initiating transmissions. This allows it to pick up energy in existing cells surrounding it and adjust its transmit power accordingly. Power zoning may also be set up as in Figure 5, since the AP will detect the portion of the spectrum existing RF energy is in with a wideband scan. With large cells, other APs may be too far away for the new AP to pick them up, but the existing APs can be programmed to boost transmit power for a period of time to guarantee pickup.

FIG 5: PowerZoning Example



There is no need for the signals from the existing APs to be intelligible 802.11 transmissions since they will be picked up by the wideband FFT (besides the full demodulating 802.11 receive paths). Using this information, the AP can be set to look for present patterns in the RF spectrum indicating where existing APs are transmitting and to determine how strong their signal is. This defines the signal power to transmit on and which channels should be used. Following this step, the loop may also be closed by programming the existing APs to check for the RF energy transmission spectrum of the new AP in a similar way to verify its transmissions are acceptable. Otherwise, the loop may be iterated with the new AP's transmit power and channels being adjusted until a desired level of non-interference is reached. The algorithm may incorporate for modification of the transmit power and channels of existing APs in addition to the new incoming AP in a straightforward way.

Automatic AP deployment, as well as several other applications further described below, works best when APs are programmed to collect information, which is then integrated and processed in one central processing node, or shared amongst multiple distributed nodes such as host processors mounted in the APs themselves. This effectively means that a complete picture of the wireless environment can be built up for all points in the wireless network as a solid basis for decision-making.

AP Network Scalability

AP Network Stability

Addition and removal of APs is seamless with full spectral monitoring. As described in the previous section, APs may be added to the network at will, resulting in large networks. New APs may be introduced at any time with automatic adjustment of transmit powers and channels in the new and existing APs. This remove the need to rigidly preserve an AP network for fear of disturbing AP cells once it has been set up. For example, lack of sufficient coverage or quality of service in one area, or the introduction of a high priority client or client group, may be rapidly remedied with the introduction of a new AP in that area. Automatic adjustment of transmit powers and channels in the new and existing APs will ensue. Removal of APs can be handled in a similar (reverse) manner.

AP Robustness

Loss of an AP due to malfunction can be picked up from APs in the adjoining cells by detection of beacon signals sent out by associated clients. It will then be possible in many cases to re-associate those clients with the remaining APs (at the cost of some reduced bandwidth for remaining clients) by increasing their transmit powers with certain limits. This is illustrated in Figure 7. The process enables the network to automatically adjust to loss until the missing AP is replaced.

Full Spectral monitoring allows for easy integration of AP Robustness algorithms as described above into high software layers. Higher receiver dynamic range in the Edgewater Wireless wideband WLAN chipset enables the remaining APs to detect the orphaned clients even though the clients are not able to increase their transmit power. No transmit power control on the client side is assumed, making AP Robustness possible even with previous generation clients.

Interference Recognition

Wideband spectral monitoring using the FFT module provided in the Edgewater Wireless chipset can detect non-802.11 interferes with ease. Higher software layers may be programmed in a straightforward manner to recognize the spectral signatures of phenomena occurring in the 2.4GHz and 5GHz bands, such as microwave ovens, cordless phones and Bluetooth or Home RF devices. The information may then be used for reporting purposes or as a basis for directing the Edgewater Wireless chipset to take appropriate action, such as to re-associate clients onto channels in quieter parts of the spectrum, hence maintaining quality of service.

FIG 6: Automatic AP Deployment

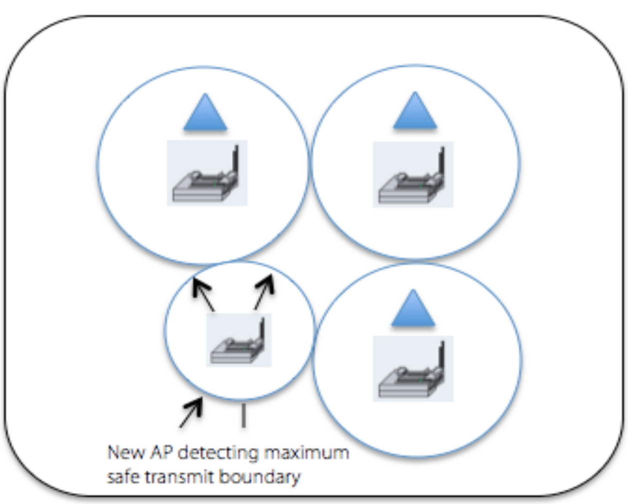
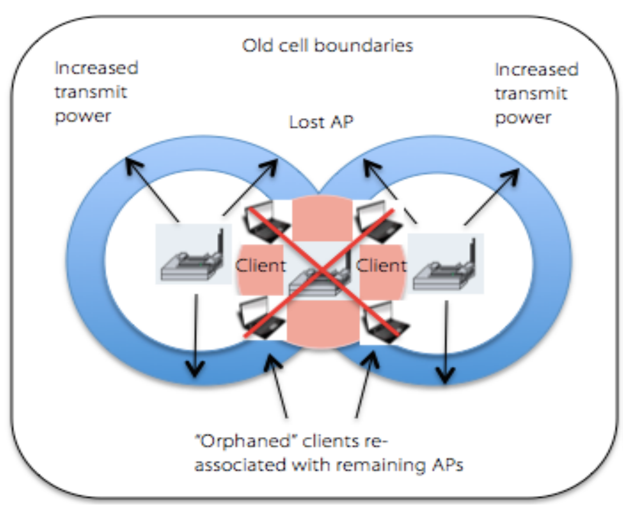


FIG 7: Robust to AP Loss

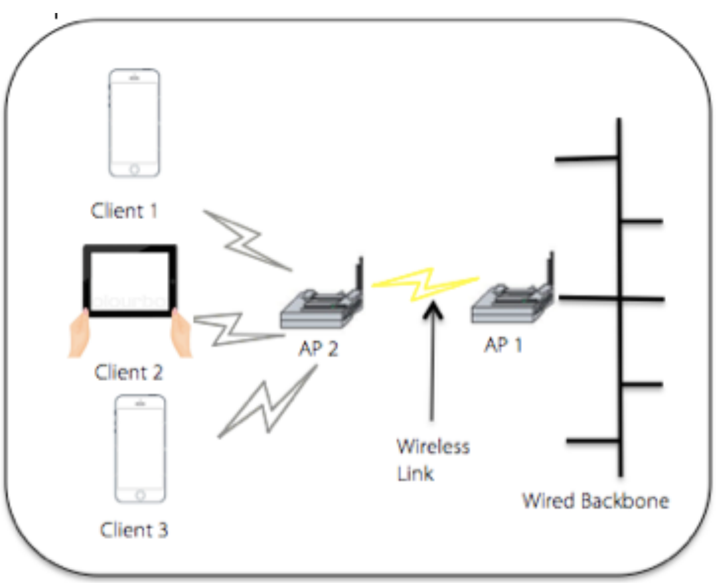


AP Network Scalability

Security and Rogue Detection

Edgewater Wireless' wideband WLAN chipset enables the continuous monitoring of the full spectrum to identify potential security risks or the presence of unauthorized transmissions. External transmissions or beacon signals can be detected easily using the full spectral monitoring features in the Edgewater Wireless wideband WLAN chipset. For example, preselected APs on the periphery of a campus may be set to look for transmissions in certain portions of spectrum and report back any RF energy detected there. FFT monitoring will pick up all RF energy, including non-802.11 transmission and can report it back to a higher layer as a potential security breach. APs may also look for rogue (unauthorized by IT management) APs within the campus in a similar way. All RF energy is picked by wideband FFT scans; this information may be passed through pattern recognition algorithms in the case of interference detection and used to make decisions on non-802.11 rogues. For example, detection of Bluetooth or HomeRF devices could be carried out in a campus adhering strictly to an 802.11- only policy.

FIG 8:



Wireless Backhaul & Mesh Network Support

With several channels now available for communication at each AP, some channels can be dedicated to communicating with other APs, thus offering a solution to situations where wireless service has to be provided but no wired Ethernet link is readily available in the vicinity. This is illustrated in Figure 8. AP 1 is connected to the wired backbone, but AP 2 is located in a less accessible location and is back-connected to AP 1 over wireless. One or more channels can be programmed to be allocated for this task, thus making the backhaul link as large as necessary. The availability of multiple channels in each AP allows for the allocation of multiple full channels to the clients, thus giving them a high bandwidth experience. For example, if AP 2 is a 6 channel AP as in Figure 3, three channels could be allocated to communication with its clients and three channels to the wireless backhaul to AP 1; no channels need to be shared.

Edgewater Wireless' wideband solution offers minimum latency in wireless backhaul situations as well as maximum bandwidth. Minimal stack processing is necessary to extract the contents of one channel and redirect it to another one in Edgewater Wireless' chipset, making the latency delay through each wireless backhaul hop only a few microseconds. This allows for the creation of deeply nested mesh networks, for example in a rapid rollout of metropolitan 802.11 "wireless clouds". The system exhibits latencies sufficiently low so as to easily support real time applications such as VoWIP, even though only a few AP nodes need tough the wired backbone.

Conclusion

Edgewater Wireless' WLAN chipset represents a true evolution in WLAN technology and is ideally suited to enabling next-generation access points. It increases the wireless bandwidth of each AP to take advantage of all channels in the WLAN bands in a scalable fashion, multiplying the bandwidth by up to an order of magnitude over previous WLAN solutions and allowing full monitoring and control of the wireless spectrum. In this manner, it enables a new generation of high speed, high quality of service, intelligent and robust WLAN access point and network deployment.

50 Hines Road, Suite 200
Ottawa ON
K2K 2M5
+1 613 271 3710
www.edgewaterwireless.com

EDGEWATER wireless