It’s all about SPEED

More data needs to be transferred and transferred faster

How often has this happened to you – you’re downloading a classic episode of “The Office” from Hulu onto your phone to kill some time while you’re waiting…maybe in an airport or a doctor’s office. Or you might be checking out some instructional or music videos on YouTube. The video is loading just fine and then it screeches to a halt. It’s not just you, it’s happening to everyone. And these wonderful new cellular capabilities we’re all enjoying are the cause of it! Data travelling across wireless networks is doubling every year, as shown in Figure 1a. Customers are expecting and demanding faster and faster data transfer rates to support the growing variety of applications running on the mushrooming number of wireless devices, shown in Figure 1b. Throughout it all, wireless service providers need to support more data, faster, with the current available finite amount of spectrum. The move to HSPA+ and 4G LTE are the most obvious routes to higher data rates, but both approaches rely heavily on a conditioned RF physical layer to deliver expected throughput.

3G and 4G data transfer rates are determined by the Signal to Noise Ratio (SNR). The better the SNR, the higher the data transfer rates. An unconditioned RF link puts at risk the ability to achieve the higher order modulation coding schemes available to LTE, UMTS HSPA and EVDO. Lower data rates mean a poor subscriber experience and underutilization of spectrum. This brief paper discusses the importance of SNR, the reality of the problem and the easy solution to deliver higher data rates on a consistent, reliable basis.

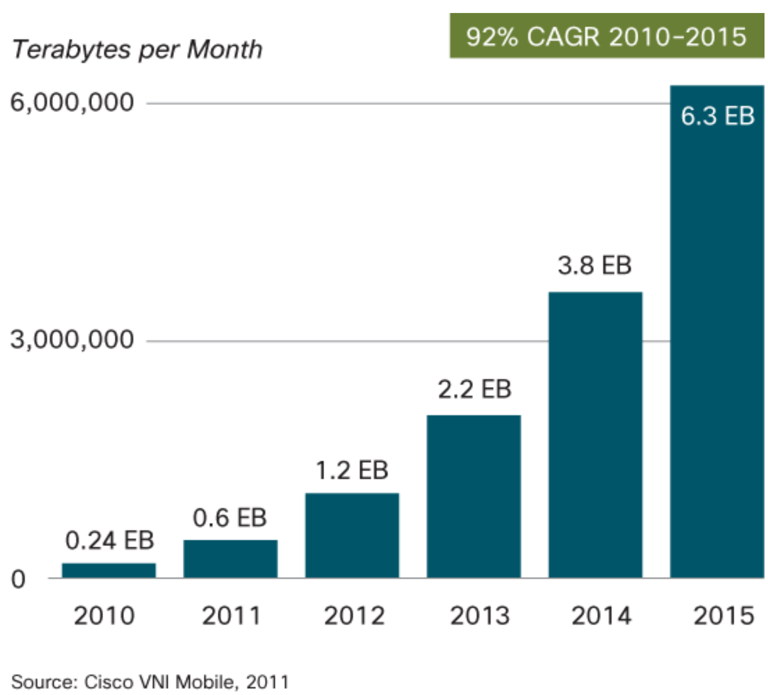

Figure 1a - Mobile Data Traffic Expected to Grow to 6.3 Exabytes per Month by 2015

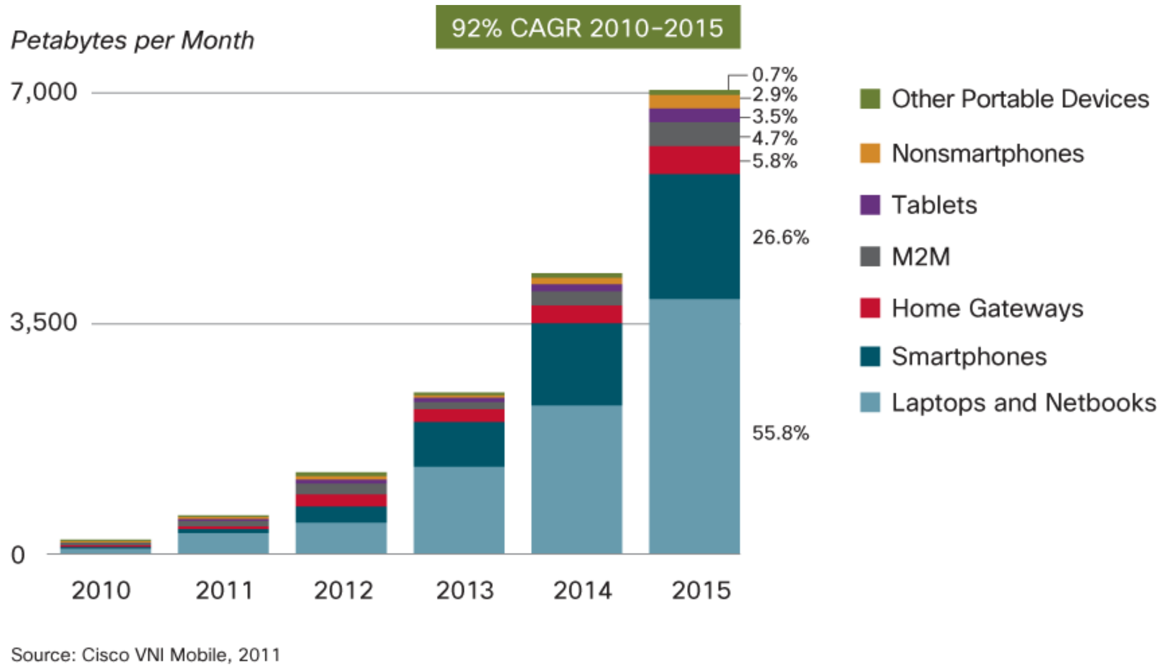

Figure 1b - Laptops and Smartphones Lead Traffic Growth

Conditioning the RF Physical Layer

The fact is, unconditioned spectrum means there is spectrum being underutilized. Said another way, there is capacity being lost or unused. However, there is the opportunity to increase data transfer rates, increase capacity, and improve coverage, but the reverse RF physical layer needs to be conditioned to ensure the best possible SNR at the Node B or eNodeB radio.

Co-channel interference and leakage from high-power adjacent RF degrade SNR and force lower data modulation rates to be used, resulting in lower data transfer rates, reduced data throughput and inefficient use of valuable spectrum. Figure 2, from the Wireless End-to-End article “Cost of Adding Network Capacity: More Spectrum or New Sites? Could There Be Other Alternatives?” illustrates how Shannon’s Law relates SNR, bandwidth, and the resulting data throughput rates that are achievable.

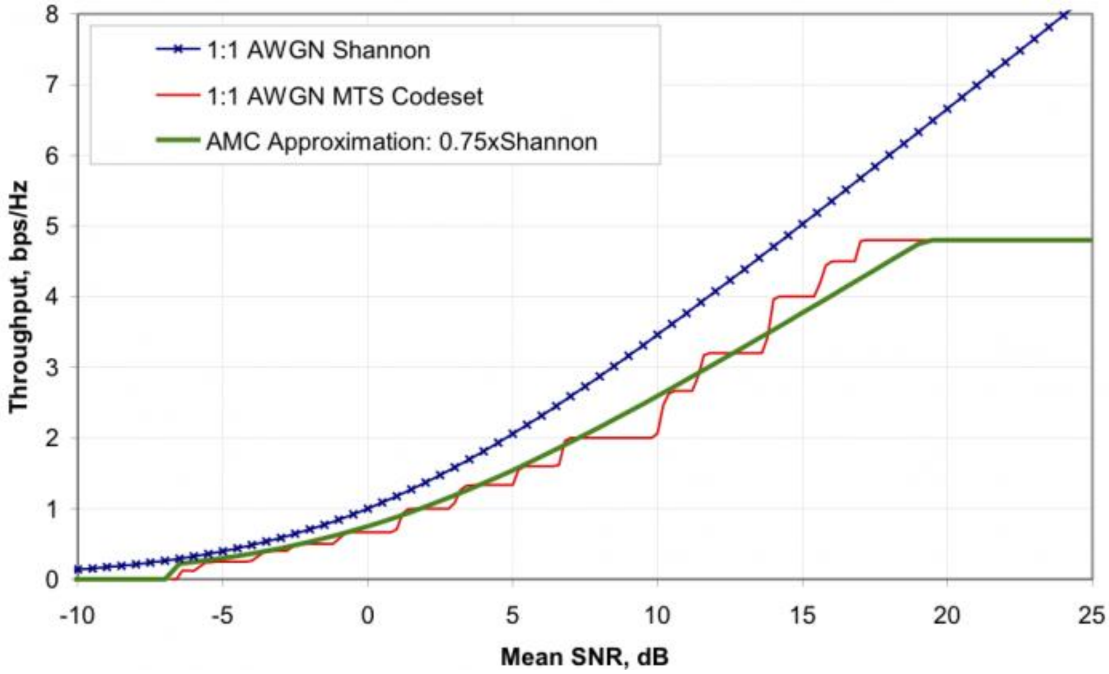

Figure 2 - SNR Dictates the Maximum Achievable Throughput

In summary, the highest modulation/coding scheme (in the arsenal of current 3.5/4G systems) is limited to about 4.8 bit/s/Hz when the SNR exceeds 19dB. In an unconditioned reverse RF link, co-channel interference and adjacent RF can degrade the channel, causing an SNR of 19 dB to be unobtainable throughout most of the coverage area. The immediate impact is reduced transfer rates and associated throughput.

Specific to LTE, in order to achieve the peak speeds exceeding 1 Gb/s for 4G, the reverse RF link must be sound or the maximum forward link rates cannot be achieved regardless of Multiple Input Multiple Output (MIMO) and bonding multiple channels together. The same holds true for 3G CDMA EVDO and UMTS modulation/coding schemes.

Using digital signal processing to condition the reverse RF link removes the negative effects of co-channel interference power and adjacent channel leakage. The method of operation is simple. The digital signal processing algorithms identify the parts of the waveform unassociated with the expected signal. Those parts of the signal are minimized resulting in an improved Carrier to Interference ratio.

Both co-channel and adjacent high power RF are real

Numerous field evaluations have found the presence of interference power in a given market's network is real – random, but prevalent. Viewing the network as a whole versus an individual site, the distribution of co-channel interference is plotted in Figure 3a. Figure 3b shows a spectral plot of a typical cell site experiencing both co-channel interference and high-power adjacent RF. All of this RF power left unchecked and allowed to impact the channel will affect SNR in a negative way and degrade the data performance.

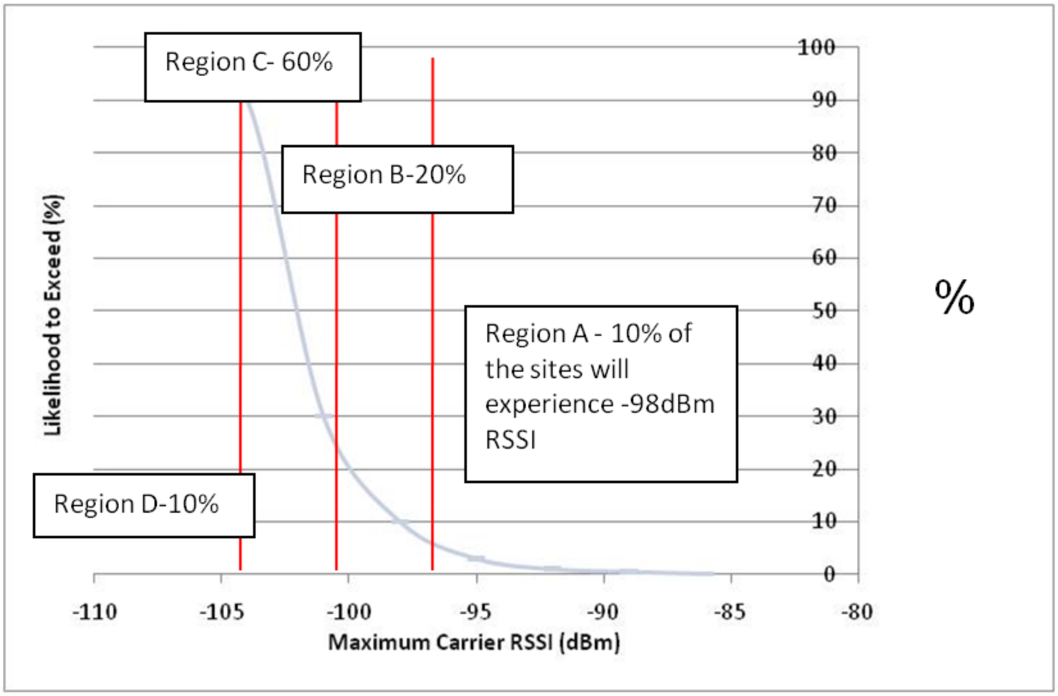

Figure 3a – Distribution of Interference in the Network

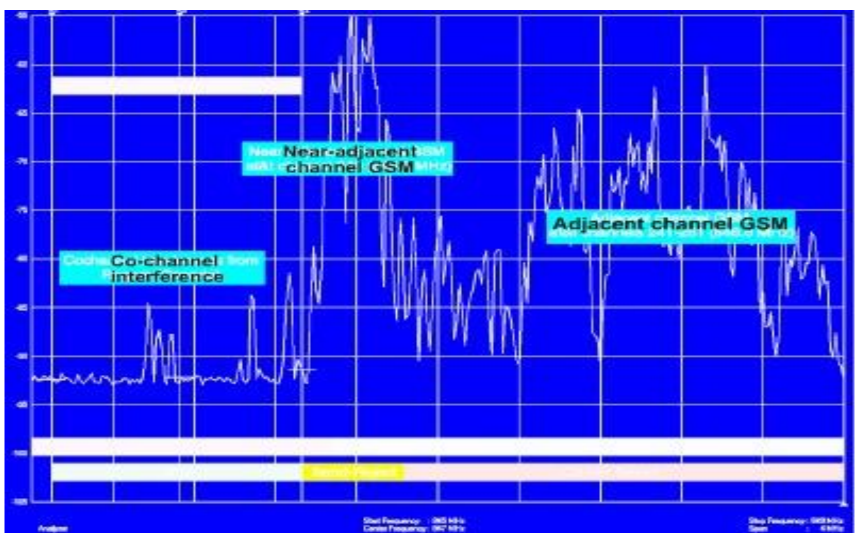

Figure 3b – The Types of Unwanted RF Power Invading the Channel and Affecting SNR

Reducing interference reduces RSSI

Figures 4a and 4b show the reduction in channel power that occurs when co-channel and adjacent channel leakage are removed from the band. Figure 4a is a before and after plot of a UMTS carrier. In this UMTS case, the RTWP in some instances was lowered by over 20 dB when the co-channel interference and adjacent RF were removed. The same result is true when removing interference power from CDMA/EVDO or LTE. In Figure 4b is an LTE channel before and after a co-channel interferer is removed. In this case, channel power was reduced by 10dB.

In all cases reducing the RSSI and RTWP will improve C to I and SNR. The resulting benefits are higher data transfer rates, greater coverage, increased capacity and reduced dropped calls.

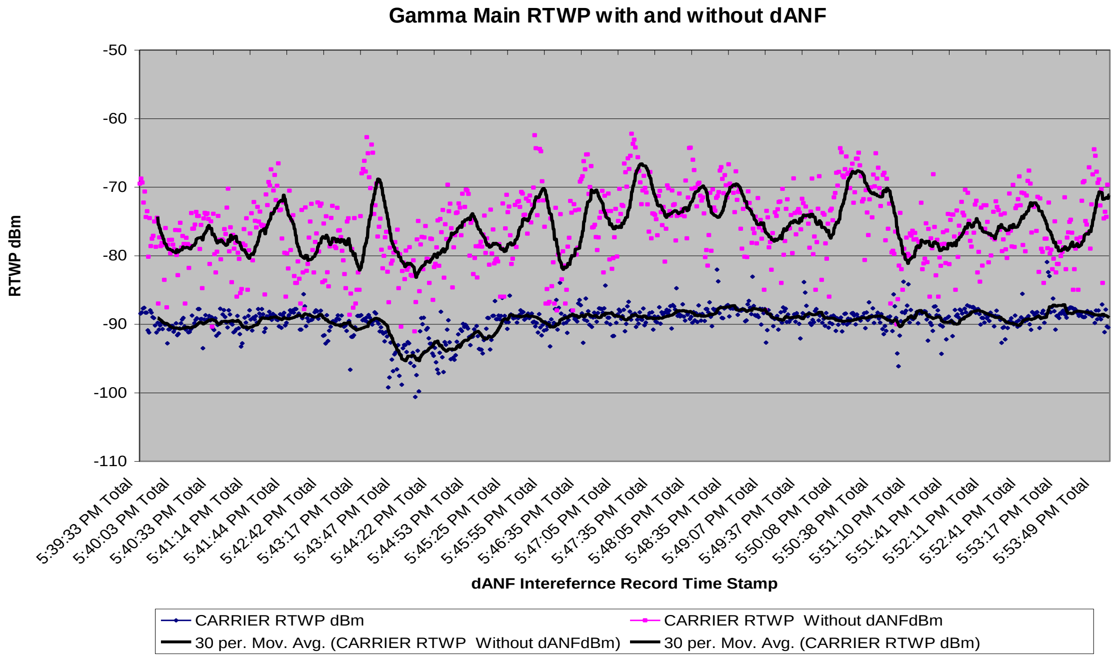

Figure 4a – RTWP Before and After Random, -55dBm Interference is Removed

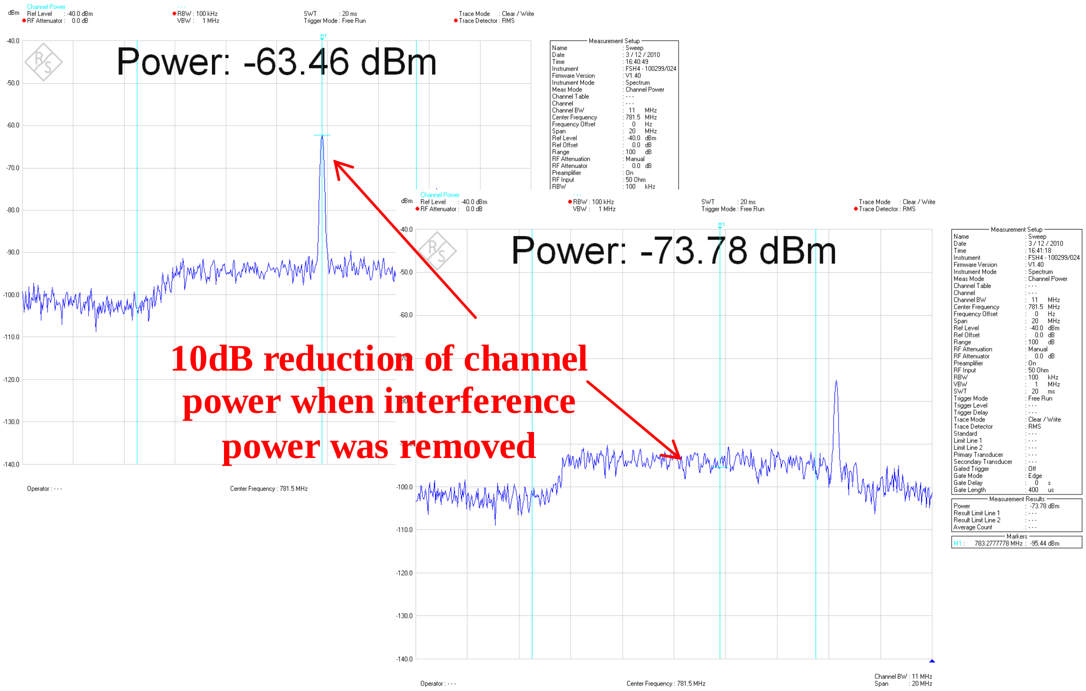

Figure 4b – An LTE Channel Before and After a Co-Channel Interferer is Removed

The result of improving C to I and ACS: SNR is improved

When SNR is improved by lowering RTWP and RSSI, data rate improves and associated throughput increases. For a cluster of cell sites in an urban area, interference power was removed from the channel allowing higher order modulation rates to be achieved. As shown in Figures 5a and 5b, the count number for the occurrence of the highest order modulation scheme was increased 108%. Similarly, the associated data throughput during the same busy hour period was increased by 43% or 540Kbps improvement in the uplink data rate. While not measured, it is presumed coverage area expanded, increasing carried traffic.

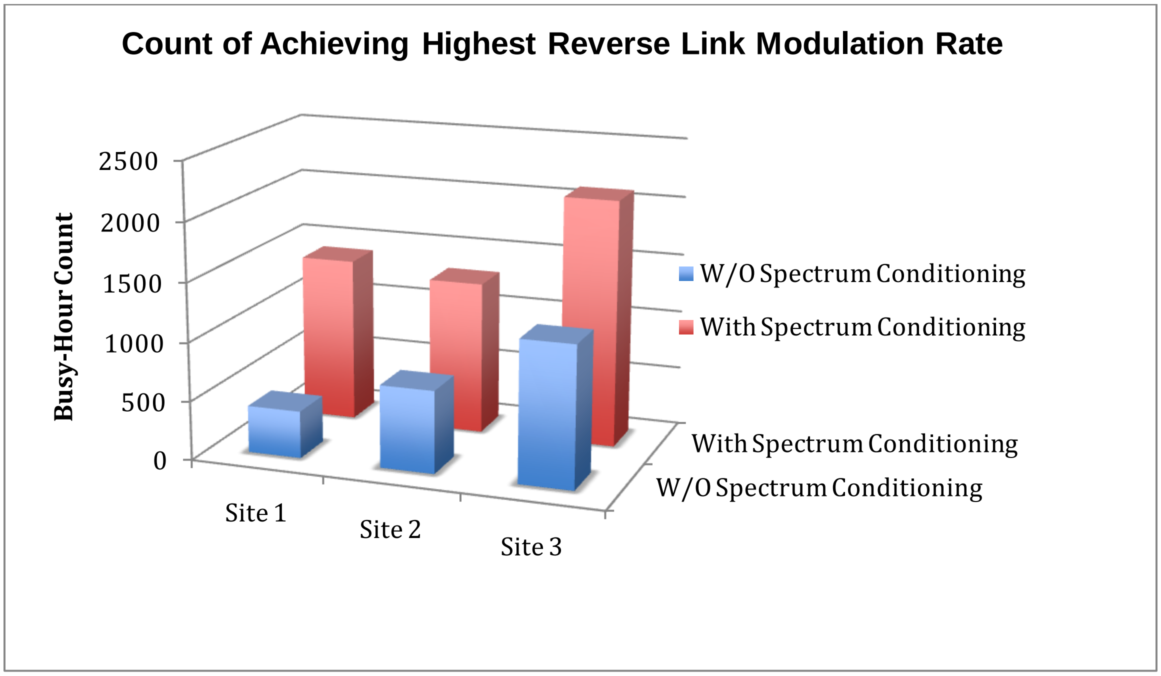

Figure 5a – Increase in Occurrence of Highest Modulation Rate

During the busy hour periods the highest order modulation rate was increased 108% compared to the similar prior period.

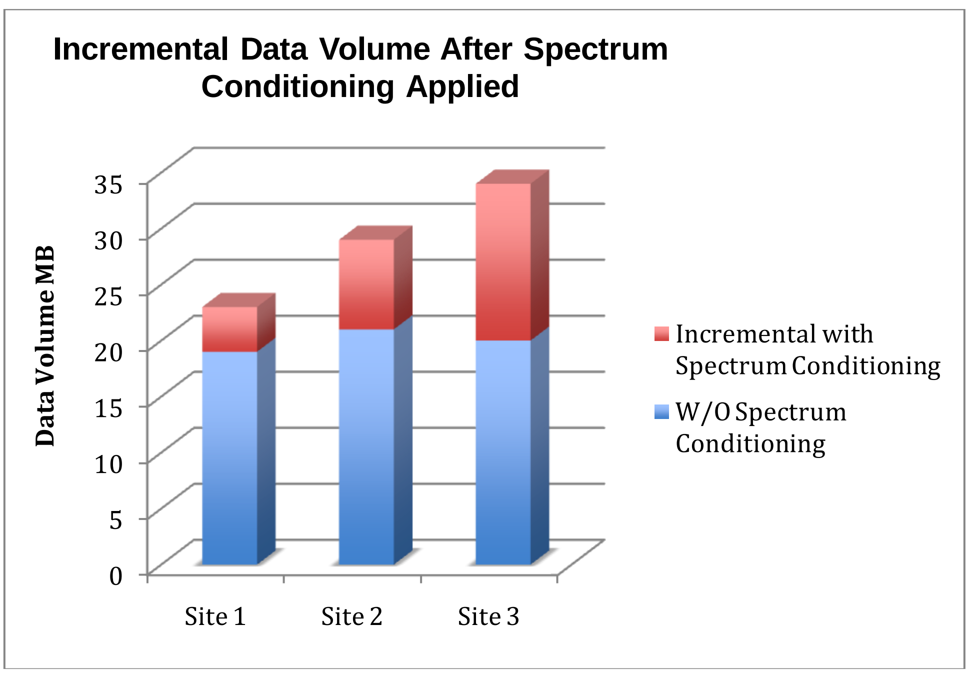

Figure 5b – Increase in Data Carried After Applying Spectrum Conditioning

During the busy hour periods 26MB more data carried was (43% increase) over the similar prior 6-day period. This was an increase of 540Kbps.

Spectrum Conditioning is not a luxury

Spectrum conditioning removes co-channel interference and high power adjacent RF that will increase channel power. The immediate result is a degraded SNR directly limiting the modulation rate / coding scheme that is used, slowing the highest possible data rates attainable. When data rates are less than maximum, spectrum is wasted and capacity is lost – the result, poor spectrum utilization and subscriber experience.

Using digital signal processing to actively condition the spectrum will improve the speed, capacity utilization and performance of a wireless network. Since numerous case studies show the condition of the RF spectrum changing randomly, implementation of spectrum conditioning becomes a necessity to utilize all available capacity and deliver the highest network performance on a consistent, reliable basis.