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Surveillance and High Speed Analysis of Wireless Gigabit Network

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Abstract: ***Wireless Gigabit (WIGIG) network is a development and promotion of high speed wireless communications in the 60GHz band technology. The demand for higher data transmission rates and advances in the 60 GHz band technology are the keys for this new technology. WiGig technology uses 60 GHz band, where the availability of higher bandwidth in this band rage and dependence on Beam forming function makes WiGig more than 10 times faster while comparing with the previous wireless communication technologies even during long distance communications. This paper mainly focuses on the two performance parameters like security, high speed analysis of WIGIG technology.WiGig ensures higher security using Advanced Encryption Standard algorithm and higher datarates are achieved with the beamforming.A systematic comparison of the performance of different Adaptive Algorithms for beam forming has been also studied in this research work.***

Keywords: WIGIG, 60GHz band communications, AES,Adaptive Beam forming,LMS,CMA.

1. Introduction

1.1. Millimeter Wave Communication

Millimeter wave generally corresponds to the radio spectrum between 30 GHz to 300 GHz, with wavelength between one and ten millimeters. In wireless communication, the term generally corresponds to a few bands of spectrum near 38, 60 and 94 GHz. Millimeter waves travel solely by line-of- sight, and are blocked by building walls and attenuated by foliage. The high free space loss and atmospheric absorption limits propagation to a few kilometers.

1.2. 60 GHz Band

The unlicensed 60 GHz frequency band has more bandwidth available than all the other unlicensed bands combined. Even for the smallest allocation, there is more than 3 GHz available, and most regions allow use of at least 7 GHz. In comparison, the 5 GHz unlicensed band has about 500 MHz of total usable bandwidth, and the 2.4 GHz band has less than 85 MHz The advantages of 60 GHz band are interference mitigation, strong security, prioritization of traffic frequency reuse and rain fade mitigation. Fig.1 shows the availability of spectrum band around the world.

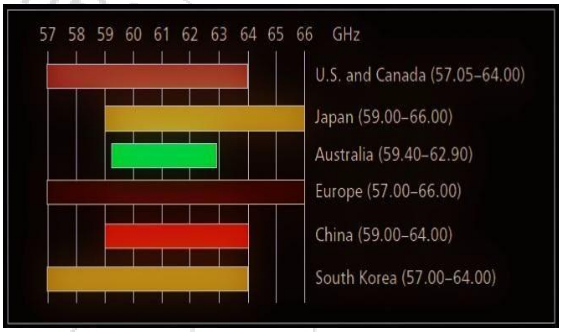

Figure 1: Availability of 60 GHz spectrum around the world.

Figure 2: Some Features of WiGig.

2. WI-GIG

WIGIG is a development and promotion of wireless communication in the 60 GHz band. Recent advances in 60 GHz technology and the demand for high speed wireless connections are the key drivers for WIGIG. WIGIG technology is designed for faster communication and faster data rate transmission from one place to the other. WiGig will operate very similarly to IEEE 802.11ac but will transmit signals in the 60GHz spectrum band, which is widely available for unlicensed use around the world. Fig.2 shows some of the features that are provided by wireless Gigabit. WIGIG offers theoretically maximum data rates of the 7Gbps and this is the highest performance given by the wireless communication technology.

2.1 Specifications

The WIGIG specification includes:

- Supports data transmission rates up to 7Gbps which is more than 10 times faster than the highest 802.11n rate.
- Supplements and extends the IEEE 802.11Medium Access Control (MAC) layer and is backward compatible with the IEEE 802.11 standard.
- Physical layer enables the low power and the high performance.
- WIGIG devices guarantying interoperability and communication at gigabit rates.
- Protocol adaptation layers are being developed to support specific system interfaces including data buses for PC peripherals and display interfaces for HDTV, monitors and

projectors.

- Support for Beam forming, enabling robust communication at distances beyond 10 meters.

3. Performance Analysis

3.1 Security

Wireless Gigabit ensures higher security and accuracy during transmission of data compared to all other technologies. The usage of Wired Equivalent Privacy (WEP) or WiFi Protected Access (WPA) / Temporal Key Integrity Protocol (TKIP) encryption methods on wireless network can dramatically reduce the throughput and makes the security weaker. This is because TKIP has known security holes while using along with the WPA.

WIGIG uses WPA2 along with Advanced Encryption Standard (AES) to provide higher security while transferring the data. WPA is a security technology commonly used on Wi-Fi wireless networks where WIGIG is the replacement and advancement of the originality of WPA. There are lot of different forms of WPA2 are available. WIGIG uses WPA2 – Pre Shared Key mode (PSK) _which utilizes keys that are 64 hexadecimal digits long and is the method most commonly used in the home networks. WPA2 – PSK is also called as WPA2 Personal in the home routers.

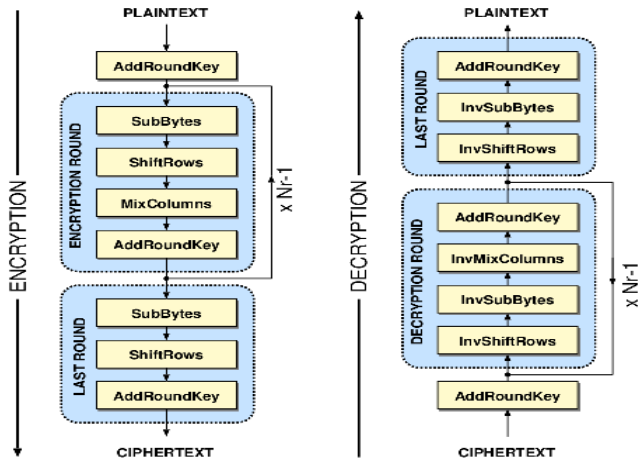

Figure 3: Basic structure of AES.

AES is symmetric key block cipher. It uses a fixed 128-bit block cipher and three key lengths supported by AES The key size used for an AES cipher specifies the number of repetitions of transformation rounds that convert the input, called the plaintext, into the final output, called the ciphertext. The number of cycles of repetition are as follows:

- 10 cycles of repetition for 128-bit keys.
- 12 cycles of repetition for 192-bit keys.
- 14 cycles of repetition for 256-bit keys.

Each round consists of several processing steps, each containing four similar but different stages, including one that depends on the encryption key itself. A set of reverse rounds are applied to transform ciphertext back into the original plaintext using the same encryption key.

3.1.1.High-level description of the algorithm:

1. KeyExpansions—round keys are derived from the cipher key using Rijndael's key schedule. AES requires a separate 128-bit round key block for each round plus one more.
2. InitialRound
   a) AddRoundKey—each byte of the state is combined with a block of the round key using bitwise xor.
3. Rounds
   a) SubBytes—a non-linear substitution step where each byte is replaced with another according to a lookup table.
   b) ShiftRows—a transposition step where the last three rows of the state are shifted cyclically a certain number of steps.
   c) MixColumns—a mixing operation which operates on the columns of the state, combining the four bytes in each column.
4. AddRoundKey
5. Final Round (no MixColumns)
   a) SubBytes
   b) ShiftRows
   c) AddRoundKey.

3.2. Speed

Higher data rates are achieved even during the long distance communications because of the major dependence on Beam forming.

3.2.1.Adaptive Beam forming:

Beamforming is the process of differentiating the spatial properties between signal and noise. The system which is used for beamforming is beam former, which is mainly used in antenna. The system receives a desired source signal radiating from a specific direction and attenuate signals originating from other directions.

$$\theta = (2\pi d) * \sin \Phi / \lambda, \ -\pi/2 \leq \theta \leq \pi/2$$

Where d is the distance between adjacent arrays, ($d<(\lambda/2)$) and λ is the wavelength of the incident wave. The adaptive beamforming can be achieved by different adaptive algorithms like LMS, NLMS, RLS, CMA, CMA_NLMS, etc. These are also called smart antenna algorithms.

3.2.2.Adaptive Beamforming Algorithms:

Adaptive Beamforming algorithms based on the approach to adjust the weights as the incoming data is sampled and keep updating it such that it converges to an optimal solution. In this study we are comparing two algorithms one is a non-blind beamforming algorithm{LMS} and other is a blind beamforming algorithm{CMA}.

i) Mathematical Model of CMA Algorithm

Constant Modulus Algorithm (CMA) exploits the constant modularity of the signal for adapting the parameters. To construct a receiver weight vector **w** such that the output signal is

$$y_k = w^H x_k$$

And the stochastic weight vector is,

$$\mathbf{w}(k+1) = \mathbf{w}(k) - \mu \mathbf{x}_k \left(|y_k|^2 - 1\right)^2 y_k$$

Similar to LMS, but with update error ($|y_k|^2$ -1)y_k .

ii)Mathematical Model of LMS Algorithm

The LMS algorithm consists of two basic processes. First is the filtering process, which computes the output of the filter and generates the error by comparing the output with the desired inputs. Second, an Adaptive process which automatically adjust the parameters in order to estimate the error from the output. The step size is

$$0<\mu<2/(M\,S_{max})$$

Where M is the number of array elements and S_{max} is the power spectral density of the signal.

The error signal (e(n)) is determined by the difference between the original signal and output of the beam former.

$$e(n) = d(n)-w^H(n)u(n)$$

Where d(n) is the desired signal and the tap-weight vectors are calculated for each iteration and it is mentioned as below equation.

$$w(n+1) = w(n)+\mu u(n)e^*(n)$$

Finally, the mean square error is estimated as

$$J(n) = E(|e(n)|^2)$$

4. Simulation Results

4.1 Security

A plaintext-key combination is given as input.For this cipher text is observed at the encryption side and at decryption it gives out the 128-bit plain text.

4.2 Speed

Simulation results revealed that Least Mean Squares (LMS) is best for beam forming (to form main lobes) towards desired user but it has limitations towards interference rejection. While Constant Modulus Algorithm (CMA) has satisfactory response towards beam forming and it gives better outcome for interference rejection, but Bit Error Rate (BER) is maximum in case of single antenna element in CMA.

4.2.1.LMS Algorithm Simulation

The graph is obtained between phase of desired signal and LMS output. Here we see two lines a red and a blue. Red is the phase of desired signal and blue is the phase of LMS output. So in this way we see there is not much difference in the desired and the obtained Output. It is obvious from the above results that by decreasing the value of the step size parameter, a faster convergence is achieved. Likewise, due to the high correlation between the transmitted signal and its multipath component, the null formed at 300 is Very shallow compared to that formed by the sample matrix inversion method.

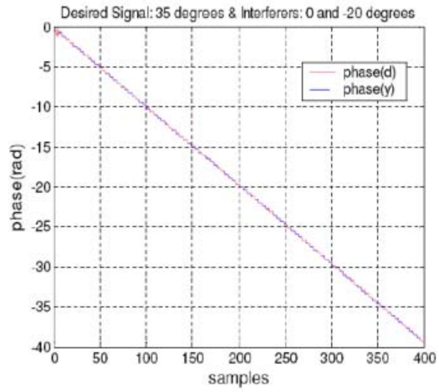

Figure 4: Phase of desired signal and LMS output

This is graph obtained between magnitude of desired signal and LMS output. In the figure we see that the LMS output is a blue line while the desired output shows a little about the LMS output line.

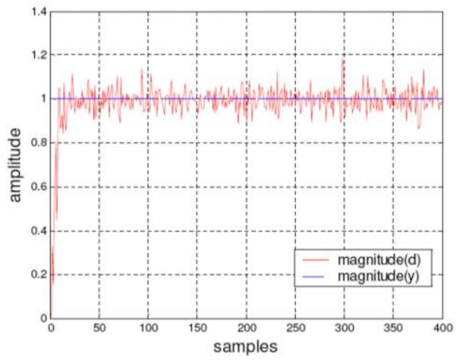

Figure 5: Magnitude of desired signal and LMS output

This is graph obtained between error between desired signal and LMS output.

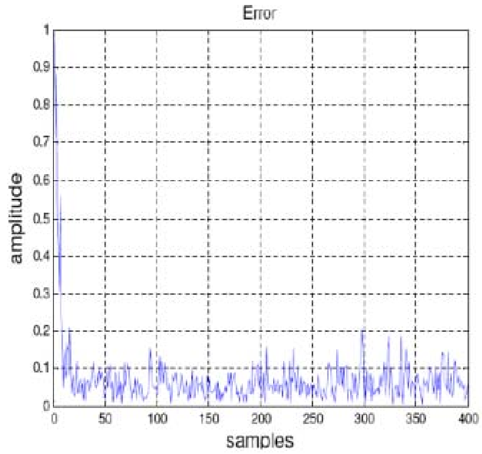

Figure 6: Error between desired signal and LMS output

This is graph is obtained for amplitude response after beam forming. It clearly depicts the plot between angle and magnitude of the L.M.S output.

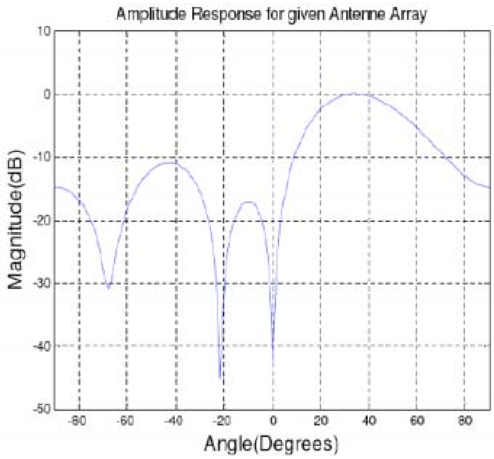

Figure 7: Amplitude Response

4.2.CMA algorithm simulation:

The graph is obtained between phases of desired signal and CMA output. Here we see two lines a red and a blue. Red is the phase of desired signal and blue is the phase of CMA output. So in this way we see there is not much difference in the desired and the obtained output.

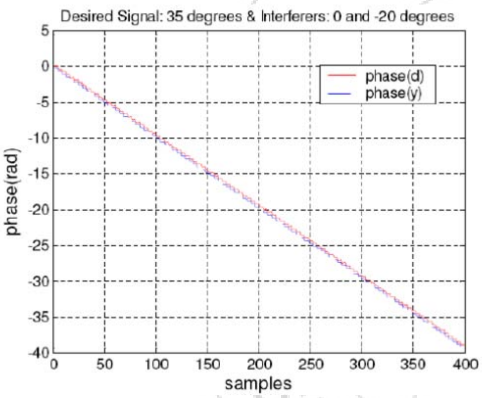

Figure 8: Phase of desired signal and CMA output

This is graph obtained between magnitude of desired signal and CMA output. In the figure we see that the CMA output is a blue line while the desired output shows a little about the Lms output line.

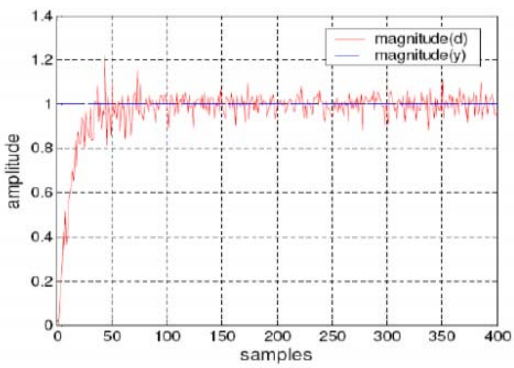

Figure 9: Magnitude of desired signal and CMA output

This is graph obtained between error between desired signal and CMA output.

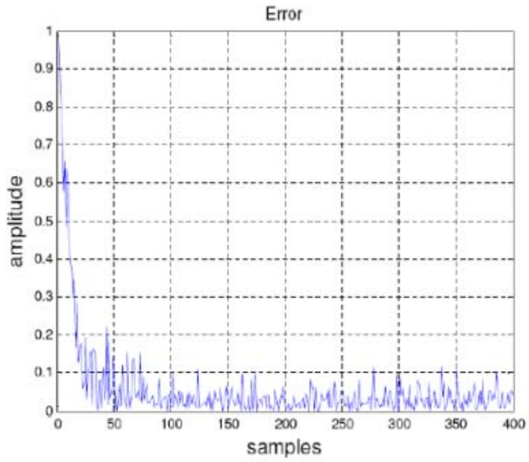

Figure 10: Error between desired signal and CMA output

In the above plot the error between desired signal and CMA output is decreasing. That is CMA output is approaching the desired signal. There will be always a minute error that is less than 0.1 which can be neglected in some cases. This graph clearly depicts the amplitude response for given antenna array. It is a plot between angle and magnitude (db).

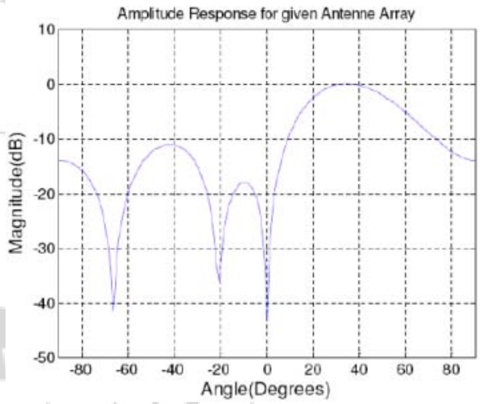

Figure 11: Amplitude Response

The LMS algorithm continuously adaptive algorithm and has a slow convergence when the Eigen values of the covariance matrix are widespread and hence the convergence takes much more time. The advantage of the RLS algorithm over Sample Matrix Inversion is that it is no longer necessary to invert a large correlation matrix. The recursive equations allow for easy updates of the inverse of the correlation matrix. The Recursive least squares algorithm also converges much more quickly than the LMS algorithm. CMA has slow convergence time which limits the usefulness of the algorithm in dynamic environments where the signal must be captured quickly.CM algorithm converges slower than LMS algorithm. During the efforts to simulate the CM algorithm it was clear that the algorithm is less stable than the LMS algorithm. CM algorithm seems to be more sensitive to gradient constant μ and also for both algorithms, μ can be calculated adaptively

5. Conclusion

Our analysis showed that the performance of WIGIG is much higher in terms of data rates, security. When compared with all other existing wireless communications. Higher data rates are provided by the higher bandwidth available in the 60GHz spectrum band. Higher data rates are achieved even during the long distance communications because of the major dependence on Beam forming. In this study we have compared two algorithms of beamforming one is a non-blind beamforming algorithm{LMS} and other is a blind beamforming algorithm{CMA}and have compared the results. Stronger security is provided by the usage of AES security technology.

The advanced features in the WIGIG shows that the future wireless communications will be dominated by the 60GHz Wireless Gigabit.

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