Modeling of 60 GHz High Speed Communication Beam forming for Wireless Personal Area Networks (WPAN)

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ABSTRACT

The current systems of networking in the industrial, scientific and medical (ISM) band are experiencing some challenges like the designing of a power amplifier with fast switching ADC, less power consumption and inherent low latency in 2.4/5GHz RF end [1][2]. Other challenges are data achievement in multigigabits with operation below 20 meters, high speed multi-file transfer, wireless gaming and wireless gigabit Ethernet that permit bidirectional multi-gigabit Ethernet traffic as well as cable replacement for uncompressed HDTV. From the above limitations of the existing systems, there is a need for a wireless solution with higher data rate and improvement in reliability of the link. The proposed 60 GHz beam forming model which utilizes Orthogonal Frequency Division Multiplexing (OFDM) based short-range communication system for Wireless Personal Area Networks (WPAN) has been subjected to various cases of analysis in both line of sight (LOS) and non-line of sight (NLOS) scenarios. In order to utilize the bandwidth allocated to this system, this research analyses the proposed beam forming model performance using three types of beam forming techniques i.e. hybrid, subcarrier wise and symbol wise beam forming. The effective SNR gain was computed for the typical channel models developed by IEEE 802.15.3c for both LOS and NLOS scenarios. In the case of LOS, it is observed that the gap between the bound and both subcarrier-wise BF and hybrid BF gain is approximately 1dB while the one between bound gain and symbol-wise BF gain is approximately 1.5 dB. It is also observed that subcarrierwise beam forming provides the best results with a gap of 3 dB in comparison with the bound in NLOS although it has hardware complexity with a requirement of one FFT/IFFT per antenna and a SVD processor per subcarrier whereas hybrid beam forming (HBF) is the next with performance gap of 5 dB while maintaining reasonable hardware complexity by employing symbol-wise BF at the transmitter which requires only one FFT/IFFT processor at each terminal and applies same weight vectors to each subcarrier; and symbol wise BF is the worst with performance gap of 10 dB in comparison with the bound. For verification of the results, BER performance for various SNR values was simulated for LOS and NLOS scenarios. In the case of LOS, it is observed that a BER of about 10-4 is achieved when the subcarrier-wise BF give a gain of 15 dB over single antenna system, which is the accepted minimum SNR to establish a connection, while both hybrid BF and symbol-wise BF achieves about 10-3 for the same gain. The simulation results in the case of NLOS scenario shows that a BER of 10-4 is achieved when the subcarrier-wise BF gives a gain of 15 dB over single antenna system while hybrid BF achieves 10-3 for the same gain and symbol-wise achieves 10-2 . The results demonstrate that all three beam forming schemes increase the system performance significantly over the single antenna system through improved link reliability due to beam forming gain. It is seen that subcarrier-wise BF provides the best performance in both LOS and NLOS scenarios although with high hardware complexity while symbol-wise BF is the worst although with low hardware complexity. A trade-off between good performance and low hardware complexity shows that hybrid beam forming provides considerable improvement while maintaining reasonable hardware complexity from the results above. Keywords: Beam-forming, WPAN, 60 GHZ, OFDM, HBF, BER, SNR.

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