The Impact of Interference from a Covert Link on a Data Link using OFDM, AMC, and Hybrid ARQ

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***Abstract*— This paper shows the impact of interference generated by a covert link on the data link layer of a packet based (infrastructure) wireless network. Infrastructure networks employ orthogonal frequency division multiplexing (OFDM), adaptive modulation and coding (AMC), and hybrid auto-repeat-request (HARQ) to allow them to achieve higher data rates and increase capacity.**

Keywords*— *Orthogonal frequency division multiplexing (OFDM), Nakagami-m fading, Interference.

I. Introduction

The adaptive mechanisms used in wireless (infrastructure) networks, such as LTE [1] provide an opportunity for covert communications. This paper addresses the data link layer performance in the presence of interference generated by a covert transmitter. The work presented here shows the impact of a covert signal on a target network that utilizes HARQ at the data link layer.

II. Assumptions

The physical layer model consists of a target transmitter/receiver pair and a covert transmitter. This model assumes that the covert transmitter is operating in the guard band closest to the sub-carriers transmitting information in the target OFDM signal. The covert and the target OFDM signal are subject to independent Nakagami-*m* fading and share the same *m* fading parameter. The channel is frequency flat. It is to be noted that while we consider a covert system, the impact can be applied to any type of interference, i.e., intentional, unintentional, co-channel, or adjacent channel interference.

We assume packet bits are distributed evenly among the sub-carriers. Receiver structures are optimum with ideal phase and frequency recovery. The target and covert signals are not orthogonal due to the non-synchronization of the signals at the target receiver. This analysis models the in-band interference from the covert as white Gaussian noise. The power from the covert interferer that lies in the target sub-carriers frequency band is set equal to white Gaussian noise.

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It is assumed HARQ with Chase combining (CC) is implemented at the data link layer. If a packet is received in error a retransmission request is sent through the feedback channel. To generate the results shown here the analysis in [4] and [5] was modified and extended to include the impact of interference.

III. Target System Performance

A resource block is comprised of 12 sub-carriers; each sub-carrier has a symbol rate of 15,000 *symbols/sec*. The covert signal is placed 15 kHz from the first sub-carrier and is characterized by a $sinc^2$ power spectrum operating at 5 dB average transmitted SNR. The covert link utilizes QPSK signaling. The symbol rate of the covert link is $1/8^{th}$ of the target OFDM system which results in an overall bit rate for the covert link that is $1/8^{th}$ of an individual OFDM sub-carrier utilizing identical M-QAM signaling constellation. The parameters of the covert link were selected to enable the covert link to operate at BER $< 10^{-2}$ in the presence of the target link.

Fig. 1 and Fig. 2 include a performance comparison with and without the covert link present for $m = 1$ (Rayleigh fading). With and without the covert link present, the OFDM performance in terms of PER and spectral efficiency follow the same trend and only show a slight deviation from the line without interference. Results are also included for other channel conditions, i.e., for different values of the Nakagami fading parameter *m*. The performance of the target system changes more as the channel conditions change from $m = 1$ to .5 or when the fading parameter goes from $m = 1$ to 2 compared to the performance degradation introduced by adding the covert link. Fig. 1 shows the PER for when $m = 1$ with and without covert presence having little difference while changing the *m* to .5 or 1 has a much greater impact. The same is also true in relation to spectral efficiency when one takes into account Fig. 2. The spectral efficiency is approximately 4 *bits/symbol* for m =1 and 3.5 and 4.25 *bits/symbol* when m = .5 and 2, respectively.

IV. Performance Tradeoffs

The performance of the target system is negatively impacted from an increase in power of the covert signal by increasing the target system PER. However, increasing the covert signal power will improve its performance by lowering the covert system BER. An increase in covert signal power will also increase its probability of detection.

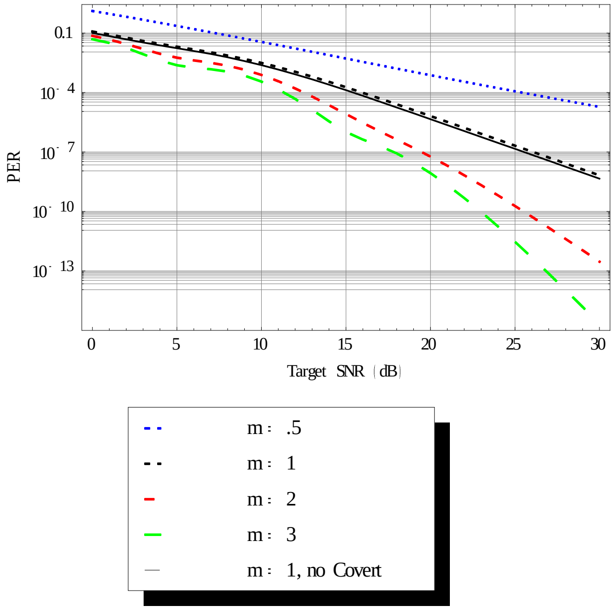

Fig. 1. PER of target system with average covert SNR = 5 dB, Nakagami-*m* fading.

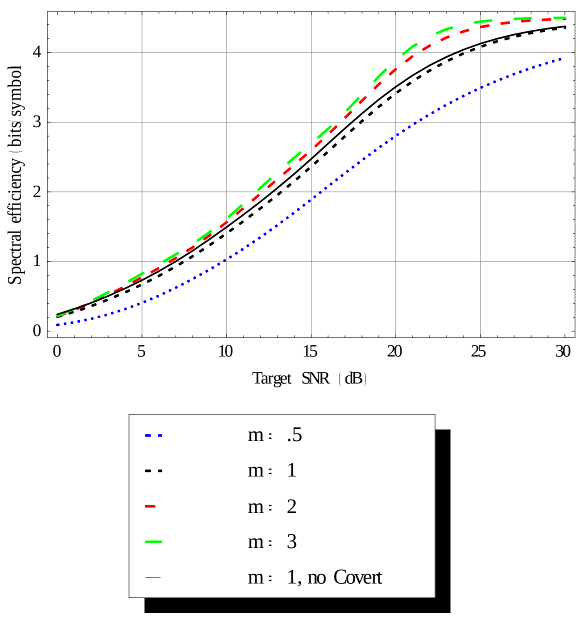

Fig. 2. Spectral efficiency of target system with average covert SNR = 5 dB, Nakagami-*m* fading.

Fig. 3 shows the impact of the increasing covert signal power on the PER. The target system sub-carrier SNR was held constant at 26.15 dB throughout this study. In Rayleigh fading, when no interference is present, a 16-QAM sub-carrier with a SNR of 26.15 dB results in a BER of approximately 0.5×10^{-3}. If we take the line for *m*=1 as a reference in Fig. 3 and 5, for average covert SNR=5 dB the PER is approximately 10^{-7} and the spectral efficiency is 4.2 *bits/symbol*; we can compare the impact of fading versus interference from the covert system. For fading parameter *m*=.5 and average covert SNR=5 dB, the PER increases to 10^{-4} while this occurs for *m*=1 at 25 dB average covert SNR, an increase of 20 dB versus a difference of .5 in the fading parameter. For fading parameter *m*=.5 and average covert SNR=5 dB, the spectral efficiency decreases to 3.6 bits/symbol where this occurs for fading parameter *m*=1 when the covert SNR= 19 dB; a difference of 14 dB versus difference of .5 in the fading parameter. It is deduced from the comparison of these observations that a change in *m* has a greater impact on the target system performance than an increase in average covert SNR.

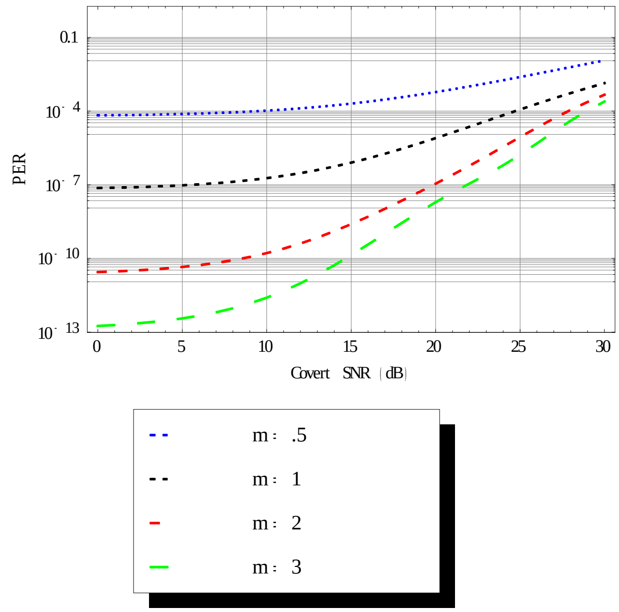

Fig. 3. PER of target system with average target SNR = 26.15 dB, Nakagami-*m* fading.

V. Conclusion

The work here demonstrated the impact of interference from a covert link on a target wireless packet based (infrastructure) system. The results show that the impact of the low power covert link on the data link layer of the target system practically indistinguishable from fading.

References

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