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Prediction of MIMO Channel Distribution with Transceiver Antenna Limitations

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Abstract: The ability of ideal MIMO channels has a high-SNR slope that equals the minimum of the number of transceiver antennas. This work evaluates if this result holds when there are distortions from physical transceiver limitations. We prove analytically that such physical MIMO/SISO channels have a finite upper capacity limit, for any channel distribution and SNR. The high-SNR slope thus collapses to zero. This appears discouraging, but we prove the encouraging result that the relative capacity gain of employing MIMO/SISO is at least as large as with ideal transceivers. The entire results will be shown in MATLAB platform effectively. **Keywords:** SNR, MIMO, Transceiver limitations, distortions

I. Introduction

Wireless communication enjoys considerable attention in the research community. Recent advances are mainly market driven by the demand for applications with increased data rates. Especially, wireless local area networks (WLANs), which aim at replacing wired computer network infrastructure with wireless communication technology, seem to raise a strong demand for further research and development. Different approaches to boost WLAN data rates have been considered in the past, as reflected in the amendments of the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard. First, data rates up to 11 Mbit/s are supported by IEEE 802.11b compliant equipment. The modulation is direct sequence spread spectrum-based, which renders wireless channel equalization a complex task in the receiver. With the introduction of orthogonal frequency-division multiplexing techniques in the popular IEEE 802.11a and IEEE 802.11g standards, data rates up to 54 Mbits/s in a bandwidth of 20 MHz can be realized with lowcomplexity channel equalization. Channel bonding, i.e., expanding the bandwidth from 20 MHz to 40 MHz, doubles the data throughput in some systems. While higher throughput is anticipated, the available bandwidth for wireless systems is generally limited. This calls for technologies that achieve a higher throughput per bandwidth, i.e., higher spectral efficiency. Especially in crowded places, such as airports, train stations, or convention centers, low system capacity provided by today's technology poses a problem, which is the cause for insufficient data rates to individual users demanding basic data services. A candidate to achieve higher spectral efficiency in next-generation equipment is multiple-input multiple-output (MIMO) OFDM technology

II. Mimo Concept

MIMO technology allows multiple antennas at both transmitter and receiver to transmit independent data streams concurrently in the same frequency band. This principle, generally known as spatial multiplexing, results in a significantly higher spectral efficiency compared to single-input single-output (SISO) systems due to spatial diversity enabling a multiplexing gain. However, the detection algorithms

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employed in MIMO receivers have generally higher computational and hardware complexity than traditional SISO detection algorithms as demonstrated. While these results concern large network MIMO systems, there is another non-ideality that also affects performance and manifests itself for MIMO systems of any size: transceiver impairments. Physical radio-frequency (RF) transceivers suffer from amplifier non-linearities, IQ-imbalance, phase noise, quantization noise,

III. Motivation for Work

Motivated by the above discussion, we hereafter analytically assess the impact of residual RF impairments inthe transmitter and receiver hardware of MIMO systems. More specifically, we derive a new analytical expression for the MIMO ergodic capacity in independent and identically distributed. Rayleigh fading channels for arbitrary SNR values. Additionally, we also present asymptotic capacity expressions in the high-SNR regime. In the low-SNR regime, we derive expressions for the minimum normalized energy per information bit required to convey any This provides valuable insights on how transceiver impairments affect large-scale (or ―massive‖) MIMO systems.

IV. System Model

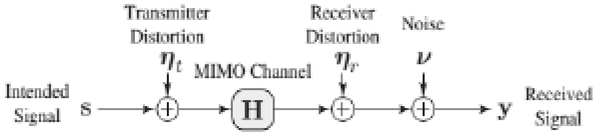
Consider a flat-fading MIMO channel with Nt transmit antennas and N_r receive antennas. The received signal is given as

$$y = \sqrt{SNR}Hx + n \qquad (1)$$

$$y = \sqrt{SNR}H\left(x + \eta_t\right) + n \quad (2)$$

Note that ηt is the mismatch between the intended signal x and the signal actually radiated by the transmitter; see Fig. 1. It is well-modeled as uncorrelated Gaussian noise as it is the aggregate residual of many impairments, whereof some are Gaussian and some behave as Gaussian when summed up

Fig 1 Block diagram of the MIMO channel with distortion noises from residual impairments in the transmitter and receiver hardware



The distortion depends on the intended signal x in the sense that the variance υn(qn) is an increasing function of the signal power qn at the nth transmit antenna .To capture a range of cases we propose

$$v_n\left(q_n\right) = k^2\left(\left(1-\alpha\right)q_n + \alpha\frac{\sum_{i=1}^{N_t} q_i}{N_t}\right) \quad (3)$$

where the parameter α ∈ [0, 1] enables transition from one(α =0) to many (α =1) subcarriers. The parameter κ > 0 is the level of impairments. This model is a good characterization of phase noise and IQ-imbalance, while the impact of amplifier non-linearities grows non-linearly in SNR. We assume to operate in the dynamic range where the impact is almost linear.

V. Channel Capacity

In a fixed wireless environment, the fading coefficients vary slowly, so the transmitter can periodically send pilot signals to allow the receiver to estimate the coefficients accurately. In mobile environments, however, the fading coefficients can change quite rapidly and the estimation of channel parameters becomes difficult, particularly in a system with a large number of antenna elements. In this case, there may not be enough time to estimate the parameters accurately enough. Also, the time one spends in sending pilot signals is not negligible, and the tradeoff between sending more pilot signals to estimate the channel more accurately and using more time to communicate to get more data through becomes an important factor affecting performance. In such situations, one may also be interested in exploring schemes that do not need explicit estimates of the fading coefficients.

$$Y = \sqrt{\frac{SNR}{M}} HX + W \qquad (4)$$

with the only difference that H is not known at the receiver, as well as the transmitter. The channel capacity and error probability are defined similarly to their coherent counterparts. The computation is, however, usually much more complicated.

VI. Outputs

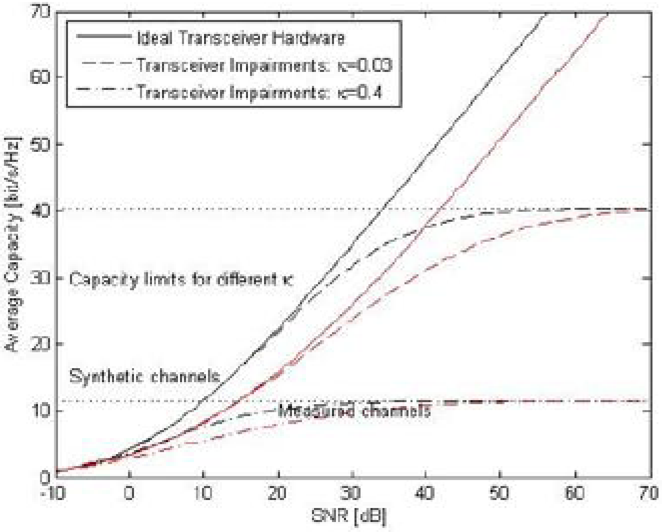


Fig 2 Average capacity of a 4x4 MIMO channel over different deterministic channel realizations, different levels of transceiver impairments, and α = 1 and k=0.03 and k=0.4

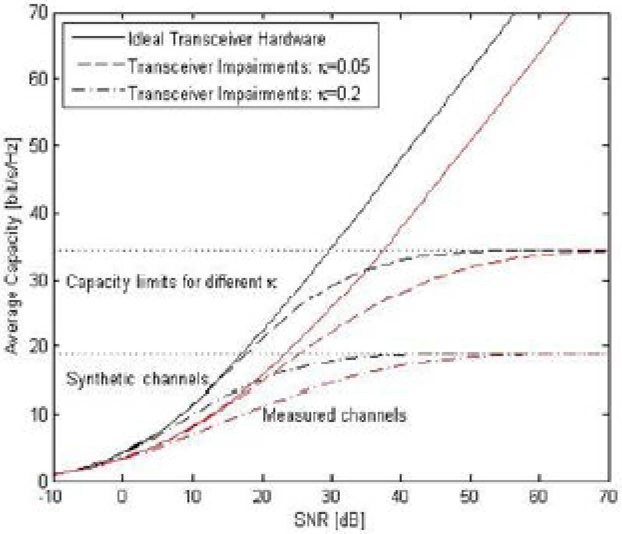


Fig 3 Average capacity of a 4x4 MIMO channel over different deterministic channel realizations, different levels of transceiver impairments, and α = 1 and k=0.05 and k=0.2

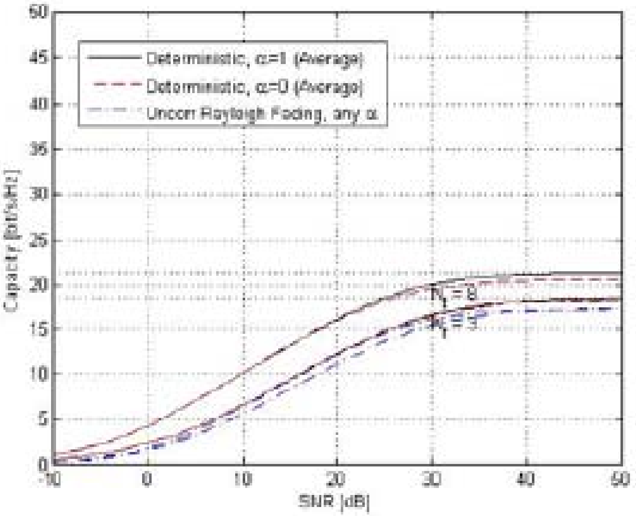


Fig 5 Capacity of a MIMO channel with Nr = 2 and Nt= 8 and 3and impairments with κ = 0.05. We consider different Nt , channel distributions, and α-values.

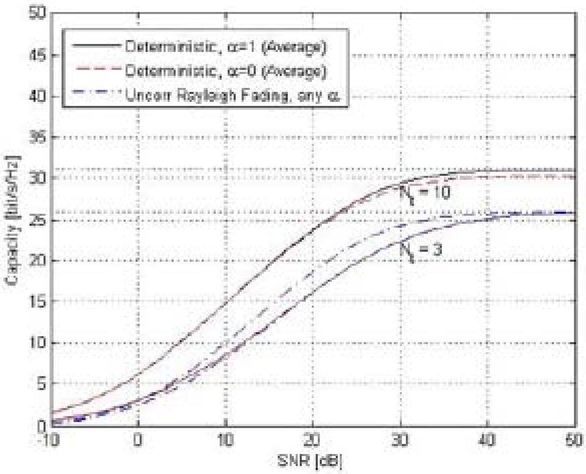


Fig 6 Capacity of a MIMO channel with Nr = 3 and Nt= 10 and 3 and impairments with κ = 0.05. We consider different Nt , channel distributions, and α-values.

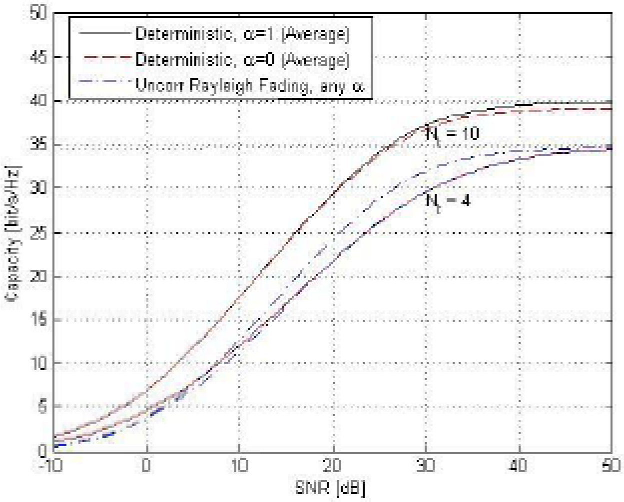


Fig 5 Capacity of a MIMO channel with Nr = 4 and Nt= 10 and 4 and impairments with κ = 0.05. We consider different Nt, channel distributions, and α-values.

VII. Conclusion

Residual RF hardware impairments can have a dramatic impact on the capacity of MIMO communication systems, especially on those operating at high SNRs (i.e., high-rate systems). In this paper, we analytically derived an ergodic capacity expression for a MIMO system with residual transceiver impairments, which applies for any finite number of antennas and the entire SNR range. This expression can be very easily evaluated, since it only contains elementary functions. This original result is explained by the distortion from transceiver impairments and that its power is comparative to the gesture power.

References

[1] F. Rusek, D. Persson, B. Lau, E. G. Larsson, T. L. Marzetta, O. Edfors, and F. Tufvesson, ―Scaling up MIMO: Opportunities and challenges with very large arrays,‖IEEE Signal Process. Mag., vol. 30, no. 1, pp. 40–60, Jan. 2013.

[2] M. Kang and M.-S. Alouini, ―Capacity of MIMO Rician channels,‖ IEEE Trans. Wireless Commun., vol. 5, no. 1, pp. 112–122, Jan. 2006. [21] R. G. Bartle,The Elements of Integration and Lebesgue Measure. Wiley Online Library, 1995.

[3] A. Lozano, A. M. Tulino, and S. Verd´ u, ―Multiple-antenna capacity in the low-power regime,‖ IEEE Trans. Inf. Theory, vol. 49, no. 10, pp. 2527–2544, Oct. 2003.

[4] Y. Zou, M. Valkama, and M. Renfors, ―Digital compensation of I/Q imbalance effects in space-time coded transmit diversity systems,‖ IEEE Trans. Signal Process., vol. 56, no. 6, pp. 2496–2508, June 2008

[5] M. Katz and S. Shamai, ―On the capacity-achieving distribution of the discrete-time noncoherent and partially coherent AWGN channels,‖ IEEE Trans. Inf. Theory, vol. 50, no. 10, pp. 2257–2270, Oct. 2004.

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