Massive MIMO: How many antennas do we need?

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(Submitted on 8 Jul 2011 (v1), last revised 23 Sep 2011 (this version, v2))

We consider a multicell MIMO uplink channel where each base station (BS) is equipped with a large number of antennas N. The BSs are assumed to estimate their channels based on pilot sequences sent by the user terminals (UTs). Recent work has shown that, as N grows infinitely large, (i) the simplest form of user detection, i.e., the matched filter (MF), becomes optimal, (ii) the transmit power per UT can be made arbitrarily small, (iii) the system performance is limited by pilot contamination. The aim of this paper is to assess to which extent the above conclusions hold true for large, but finite N. In particular, we derive how many antennas per UT are needed to achieve \eta % of the ultimate performance. We then study how much can be gained through more sophisticated minimum-mean-square-error (MMSE) detection and how many more antennas are needed with the MF to achieve the same performance. Our analysis relies on novel results from random matrix theory which allow us to derive tight approximations of achievable rates with a class of linear receivers.

Comments:	6 pages, 3 figures, to be presented at the Allerton Conference on Communication, Control and Computing, Urbana-Champaign, Illinois, US, Sep. 2011
Subjects:	**Information Theory (cs.IT)**
Cite as:	**arXiv:1107.1709 [cs.IT]**
	(or **arXiv:1107.1709v2 [cs.IT]** for this version)

Submission history

From: Jakob Hoydis [view email]
[v1] Fri, 8 Jul 2011 19:47:15 GMT (228kb,D)
[v2] Fri, 23 Sep 2011 08:18:15 GMT (228kb,D)

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