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A different look to massive MIMO

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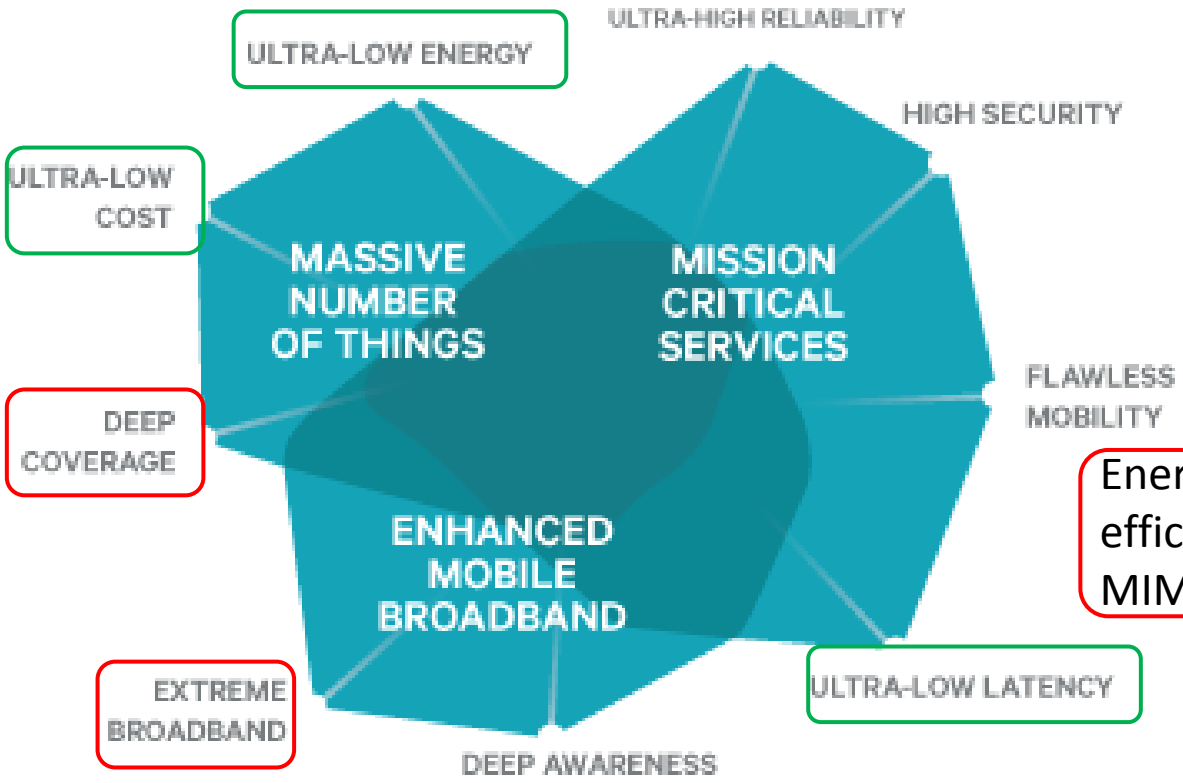
Agenda

- Introduction to Massive MIMO
- Wearable massive MMO
- Non-coherent massive MIMO
- Conclusions

Introduction

- New requirements call for new technologies



Energy- and spectral-efficiency of massive MIMO

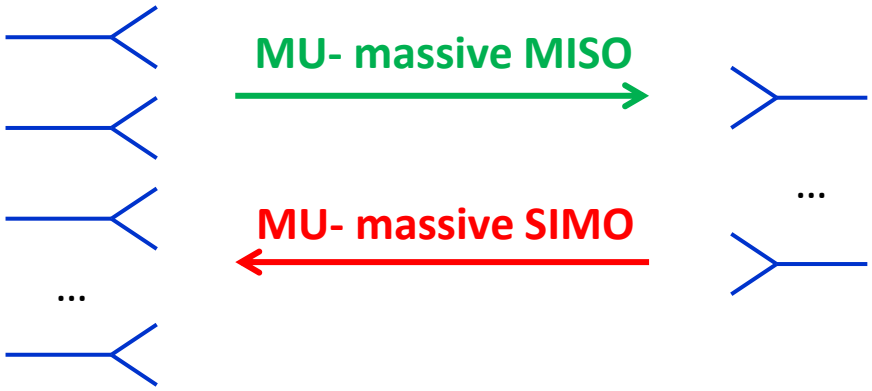
Need low-complexity solutions with reduced feedback

Massive MIMO

- Benefits of increasing (a lot) the number of antennas
  - Improve data rates and reliability (multiplexing and diversity gains)
  - Decrease required transmit power
  - Very simple precoders/decoders

Massive MIMO – most usual configuration

- Asymmetry in the number of antennas at both edges



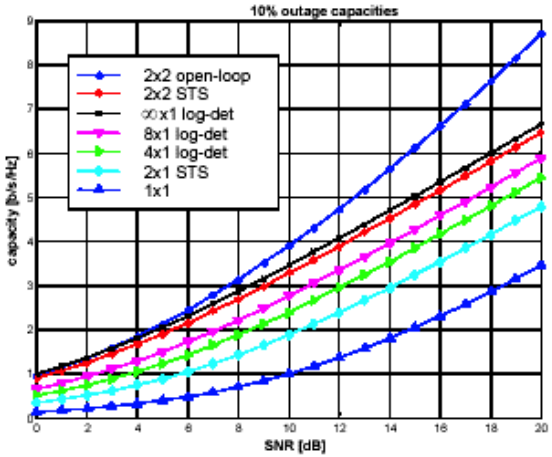
R antennas at BS, *R* >>

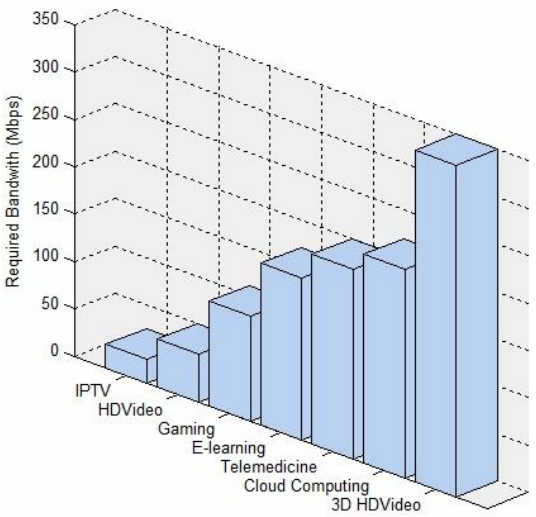
K single antenna users, *K*<<*R*

- Time division duplex (TDD)
  - the required channel estimation for precoding and coherent detection is feasible
  - calibration to compensate the differences in RF is needed
  - pilot contamination remains as a problem to solve

Why not using massive MIMO also at the UE?

- In terms of capacity for a given user, MIMO 2 x 2 is better than ∞ x 1

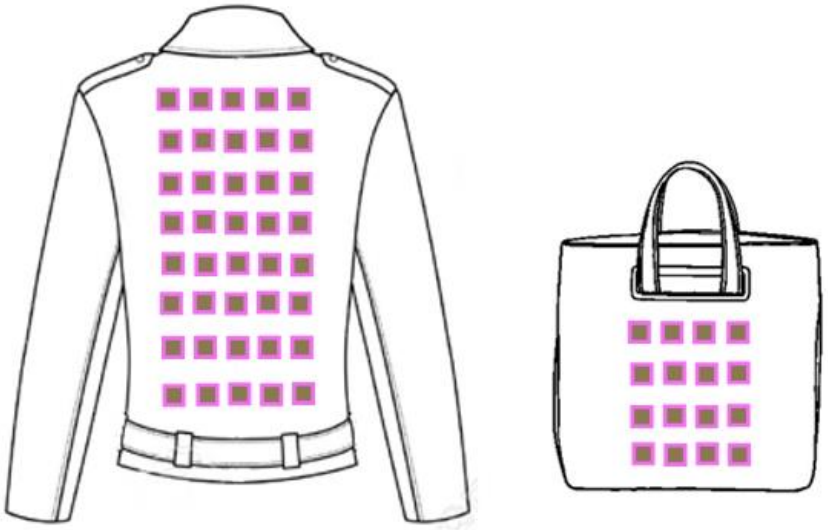




- How to accommodate a massive number of antennas at the UE?

Wearable Massive MIMO hub with textile antennas

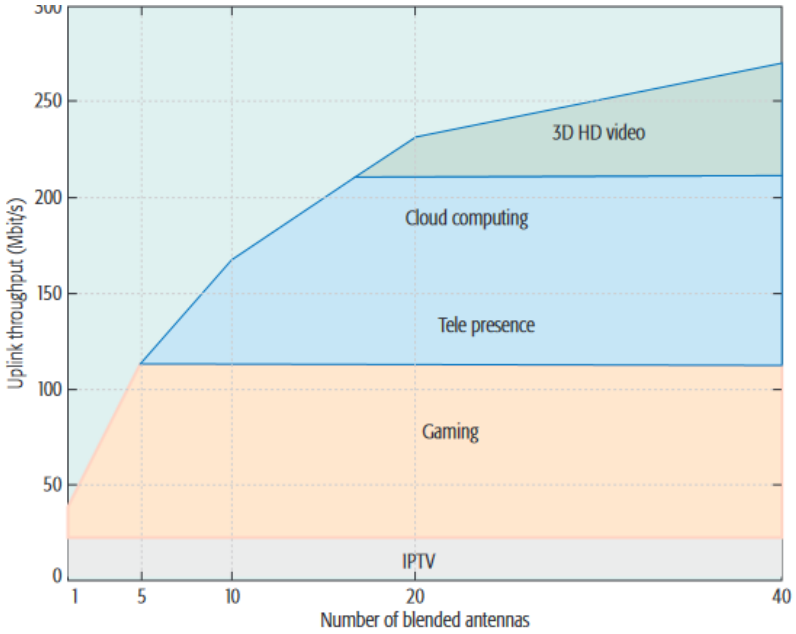
- MIMOtex is a wearable antenna hub at the user end to which any data-enabled device can connect
  - to dramatically boost symmetric wireless capacity,
  - without compromising device size and weight



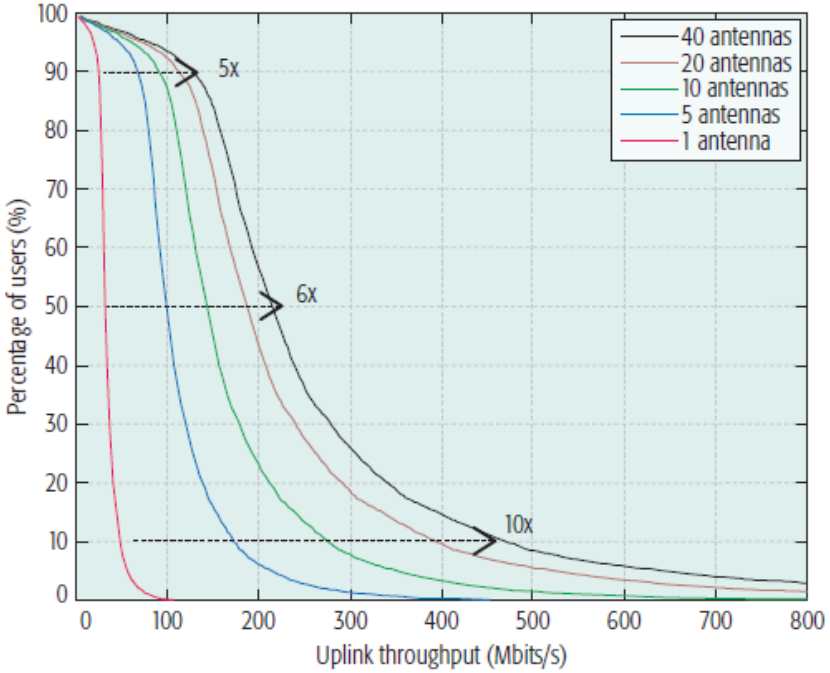
Examples of textile antenna arrays deployed at user clothing

[3] M. Sanchez-Fernandez et al. ,"Blended Antenna Wearables for an Unconstrained Mobile Experience", IEEE Comm. Mag. Vol. 55, no. 4, pp. 160 – 168, April 2017

Improving throughput and/or coverage



Average UL throughput

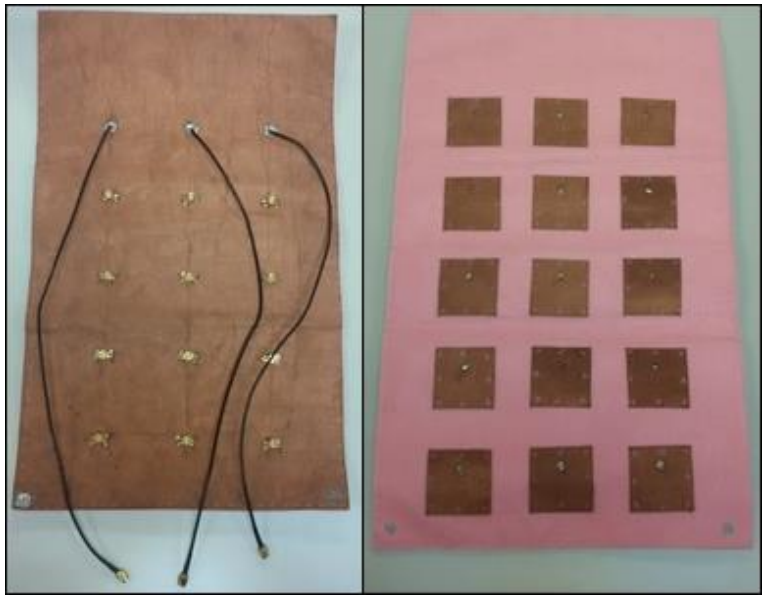


Percentile of users achieving a certain uplink throughput

bandwidth of 5MHz and 64 antennas at BS

Prototype

- Focus on the UL to reduce the impact on the BS
- Very light antennas (3 grams)
  - The substrate used is common felt
  - The metallization is implemented with electrotextile materials



Real 5x3 textile prototype developed at UC3M

Inter-element distance of 0.66λ (8 cm) @2.5GHz.

Non coherent communications – why now?

- 3 dB loss of non-coherent (NC) vs coherent (C) processing
- When we consider the needs of channel state information (CSI) obtaining and sharing, this loss may become negligible
  - A. Goldsmith's work: To train or not to train? Channel estimation is wasteful in some circumstances (channels with low coherence time, low SNR)
- NC massive MIMO: the perfect match!
  - The "magic" of massive MIMO (self interference cancellation) may improve NC performance
  - CSI estimation and sharing is vey complex in massive MIMO (pilot contamination ...)

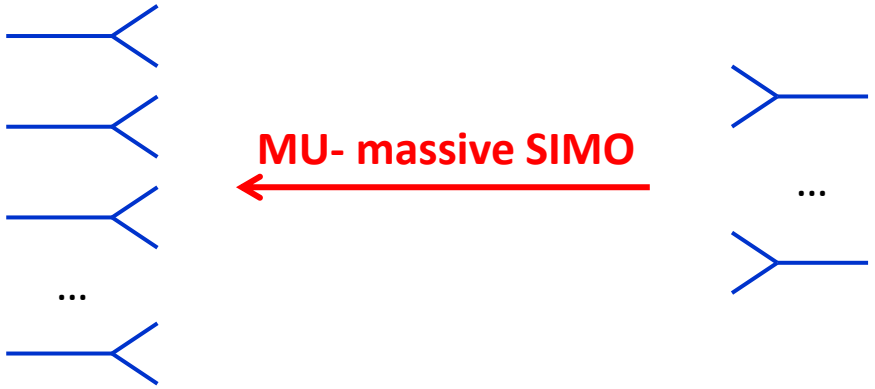
Multi-user Large Scale single input-multiple output (SIMO) uplink [4]

- One base station (BS) with *R* receive antennas
- *K* Mobile Stations (MSs) with single antenna
- Data symbol sequences $s_j[n]$ (j=1,…K) are M-PSK:

$$\mathfrak{M}_j = \{s_{j,m}, m = 0, 1, \ldots, \mathrm{M}\} \qquad |s_{j,m}[n]| = 1$$

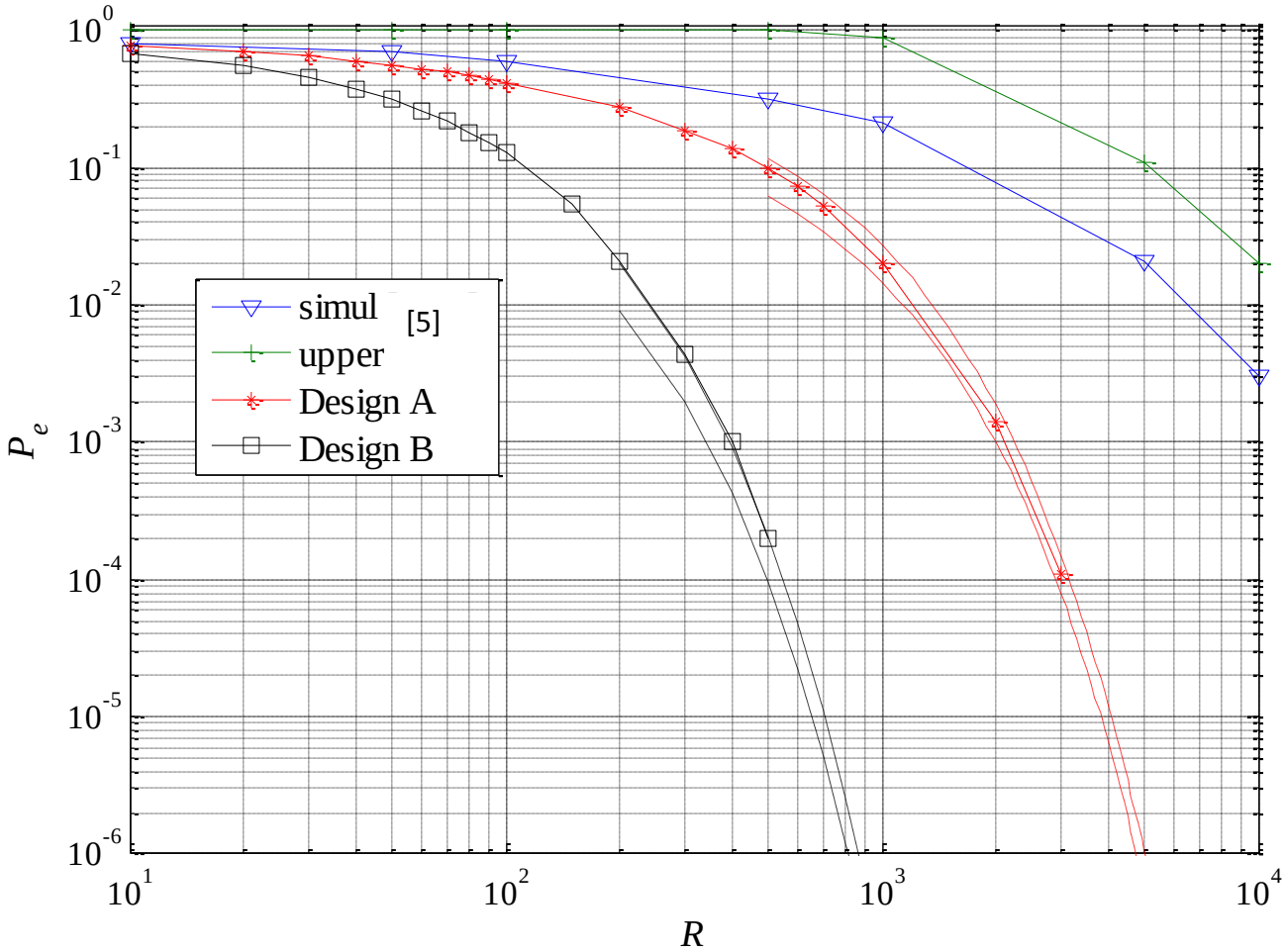
- Tx signal at time instant *n* comes from differentially encoding $s_j[n]$:

$$x_j[n] = x_j[n-1]s_j[n], n > 1$$



[4] A. G. Armada and L. Hanzo, "A Non-Coherent Multi-User Large Scale SIMO System Relying on M-ary DPSK," IEEE ICC, Jun. 2015 pp 2517-2522.

Performance – 2 users, DQPSK, SNR=0 dB



[5] M. Chowdhury, A. Manolakos, A.J. Goldsmith, "CSI is not needed for Optimal Scaling in Multiuser Massive SIMO Systems," Proceedings of ISIT., Honolulu, July 2014.

Number of antennas vs coding rate

	Outer RSC	Required number of antennas R for each SNR: users 1,2 EEP				
		0 dB	3 dB	6 dB	-3 dB	-6 dB
Coding rate	1/10	20	20	20	50	120
	3/20	30	20	20	70	180
	1/5	40	20	20	90	230
	1/4	50	25	20	110	280
	3/10	55	30	20	125	310
	7/20	60	35	25	140	370
	2/5	70	40	30	110	440
	9/20	80	45	30	170	500
	1/2	90	50	35	200	550
	11/20	100	60	40	250	650
	3/5	120	65	45	270	750
	13/20	130	75	55	300	850
	7/10	150	90	60	350	1000
	3/4	180	100	70	400	1150
	4/5	210	120	85	500	1300
	17/20	260	150	100	600	1600
	9/10	350	180	130	750	1900

Conclusions

- Massive MIMO: energy- and spectral-efficiency
  - Theory well established
  - It is time to solve implementation issues
- Massive textile antenna hub to implement Massive MIMO at UE
  - User throughput and coverage improvements
- Non-coherent DMPSK for massive MIMO does not need CSI
  - Coding reduces the number of antennas to feasible values

Thank you!

This is joint work with :

- **Matilde Sánchez-Fernández, Eva Rajo-Iglesias, Antonia Tulino, Jaime Llorca, Estefanía Crespo (MIMOtex)**
- **Victor Monzon Baeza, Wenbo Zhang, Mohammed El-Hajjar, and Lajos Hanzo (non-coherent mMIMO)**

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