Beamforming for Interference Mitigation in Femtocells

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- What is beamforming?
- What are femtocells?
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Background

- Work presented here carried out mostly in Barcelona during a 6-month research visit at Universitat Politècnica de Catalunya (UPC) in the Signal Processing and Communications group

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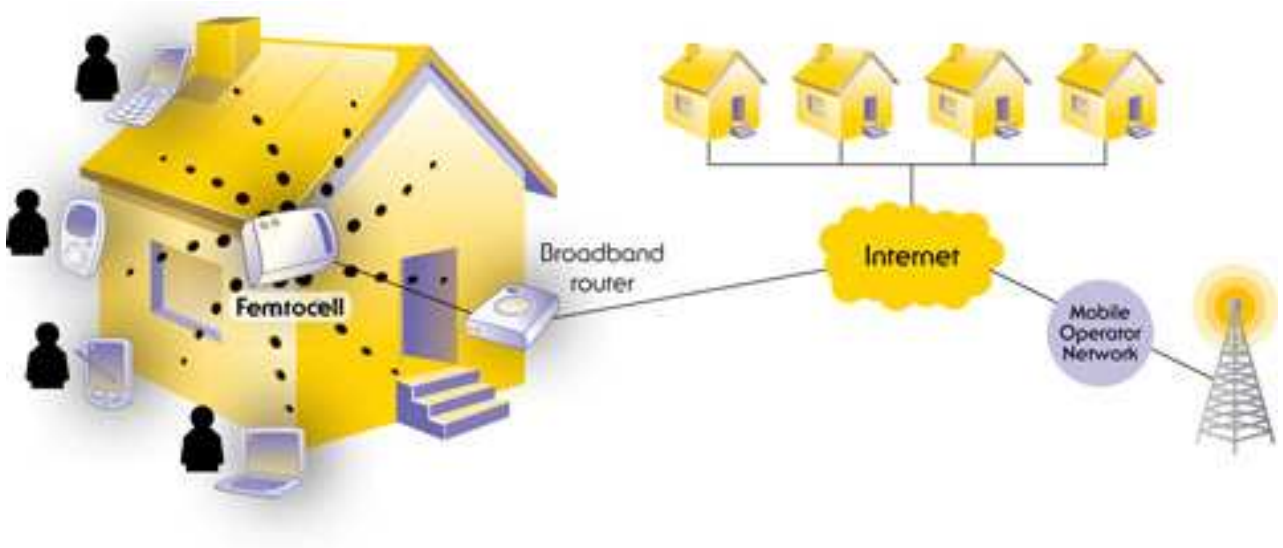
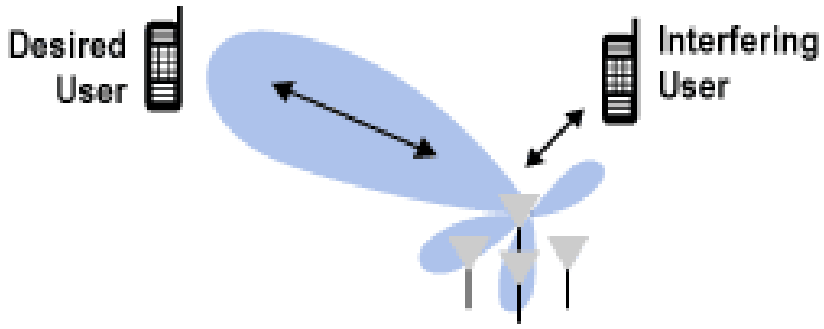
What are femtocells?

- “Low-power wireless access points that operate in licensed spectrum to connect standard mobile devices to a mobile operator’s network using residential DSL or cable broadband connections. “
  – Femto Forum (24.5.2011)



Beamforming

- ”Classical beamforming achieves increased SINR by phase adjustments of the signals transmitted on the different antennas with the aim of making the signals add up constructively on the receiver side”



Sources: 3G Americas (2009) and Altera (2011)

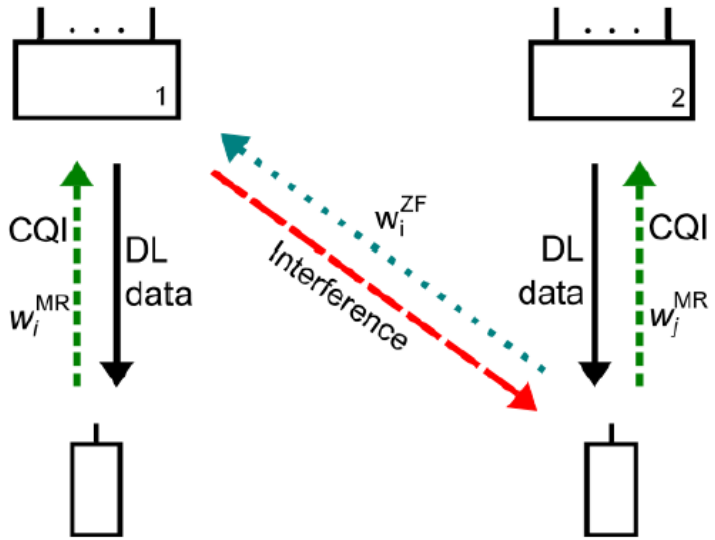
Balancing Egoistic and Altruistic Transmit Beamforming in Femtocell Networks

M. Husso, A. Dowhuszko,
J. Hämäläinen, A. Pastore, and
J. Fonollosa

Study setup

- 2 Femto Access Points – 2 Users
- 2 TX antennas in each FAP and 1 RX ant in each FUE
- Equal gain transmission

  - perfect phase alignment, no amplitude align.



Balancing Egoistic and Altruistic Transmit Beamforming in Femtocell Networks

- Idea: instead of **increasing the SINR of the own user ($\mathbf{w}_{MR}$)** or **decreasing interference to the neighboring** cell user **($\mathbf{w}_{ZF}$)** we try to **find a compromise of the two**

$$\mathbf{w}_k^{\mathrm{PO}}(\lambda_k) = \frac{\lambda_k\,\mathbf{w}_k^{\mathrm{MR}} + (1-\lambda_k)\,\mathbf{w}_k^{\mathrm{ZF}}}{\|\lambda_k\,\mathbf{w}_k^{\mathrm{MR}} + (1-\lambda_k)\,\mathbf{w}_k^{\mathrm{ZF}}\|} \qquad \lambda_k \in [0;1]$$

λ is a constant that shifts the between altruistic (λ=0) and egoistic (λ=1) beamforming

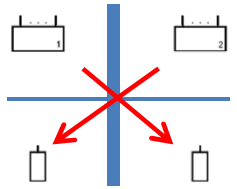
(To be presented 14.6. in the Mobile Network Summit 2011 in Warsow, Poland)

Simulation assumptions and cases

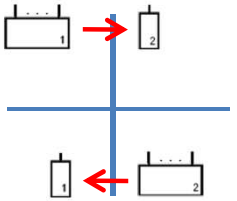
- Monte Carlo simulation (N = 15000)
- 10 dBm per antenna transmit power, zero antenna correlation, Rayleigh fading, thermal noise -174 dBm/Hz

	Attenuation Tx→Rx [dB]				**Add. interf. [dBm]**
Case	1→1	1→2	2→1	2→2	→1 and →2
1a	60	75	75	60	none
1b	60	75	75	60	-50
1c	60	75	75	60	-65
2a	75	60	60	75	none
2b	75	60	60	75	-50
3a	60	60	75	75	none
3b	60	60	75	75	-50

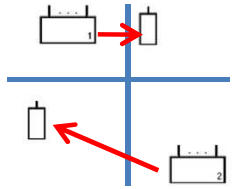
Case 1x



Case 2x

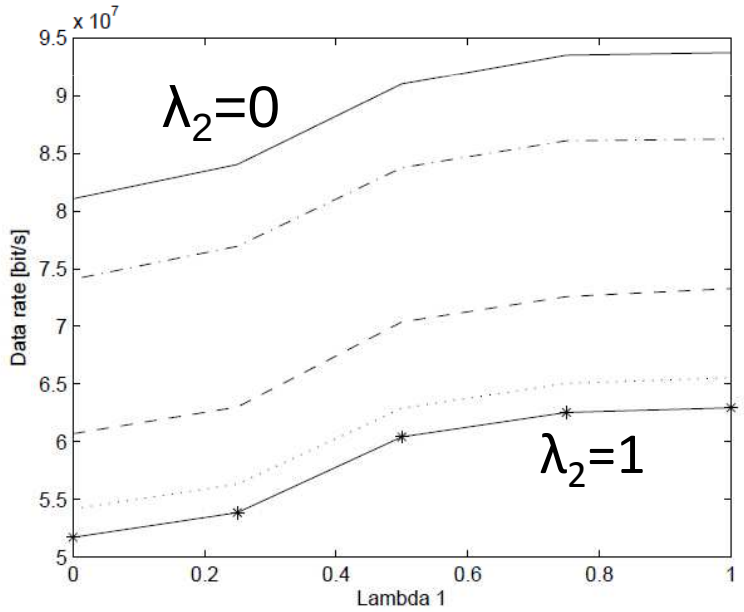


Case 3x

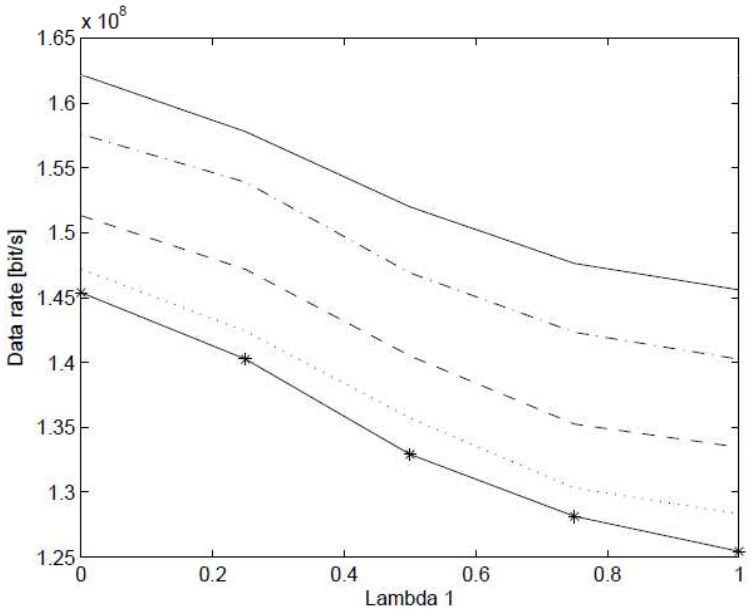


Results (Case 1a)

- High SINR case
- No additional interference



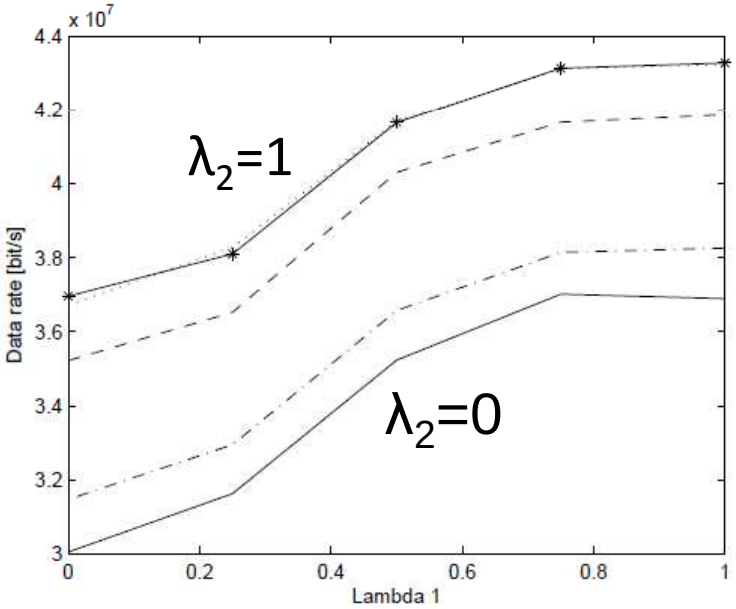
(a) User 1



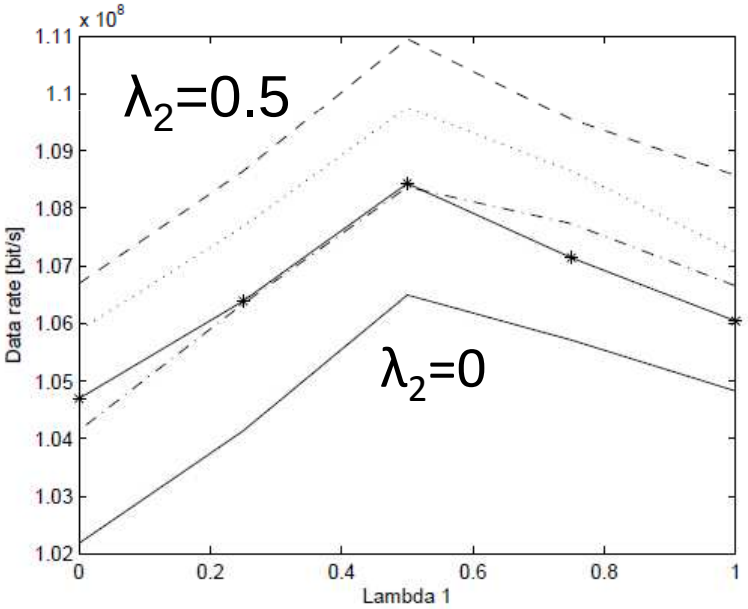
(b) Sum rate

Results (Case 1b & 1c)

- High SINR case
- Add. interference -50 dBm (b) and -65 dBm (c)



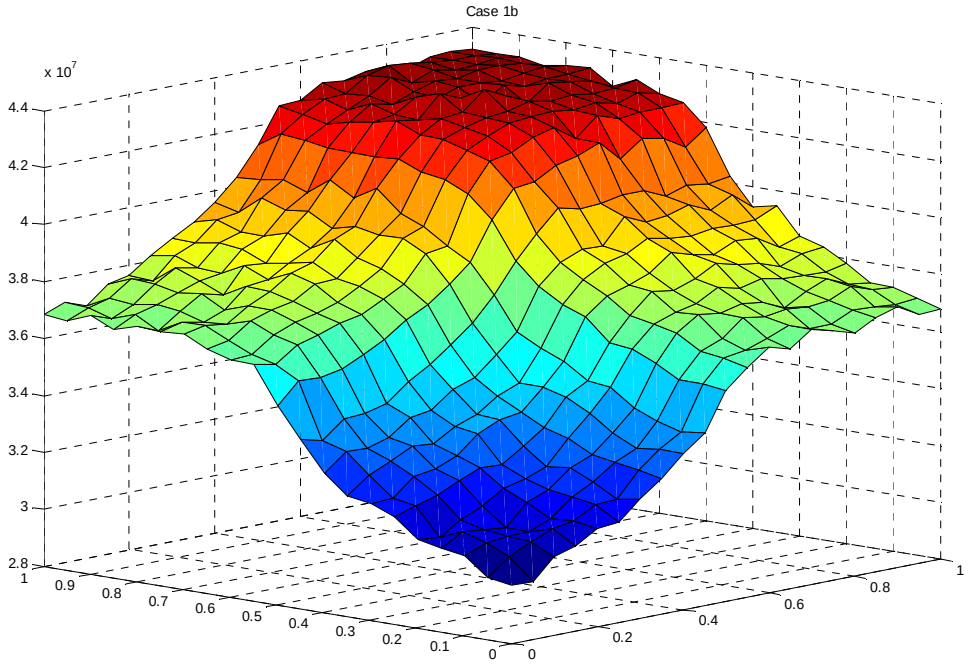
(a) Case 1b

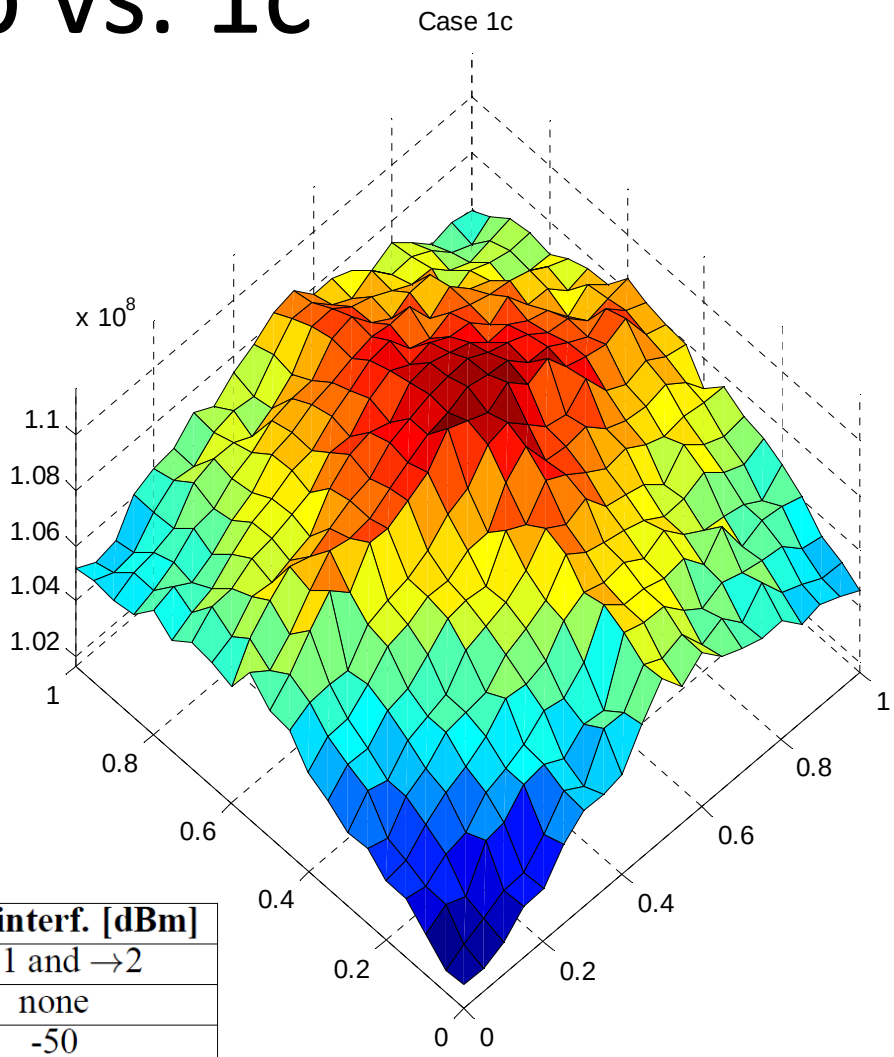


(b) Case 1c

Sumrate

Case 1b vs. 1c

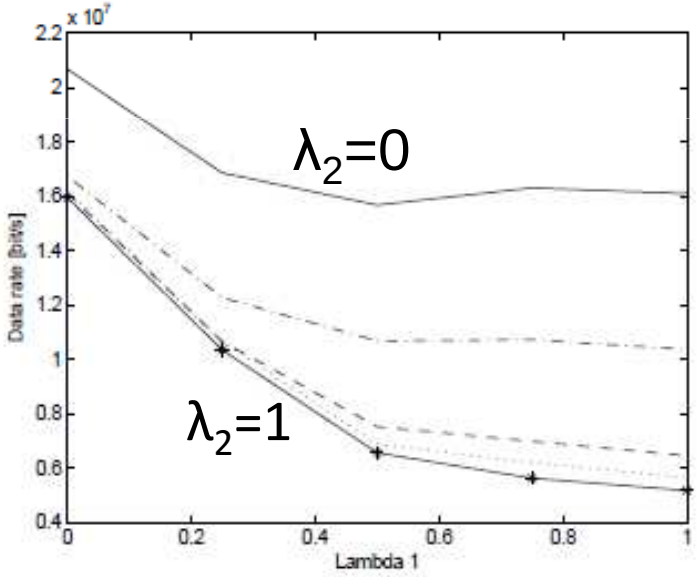




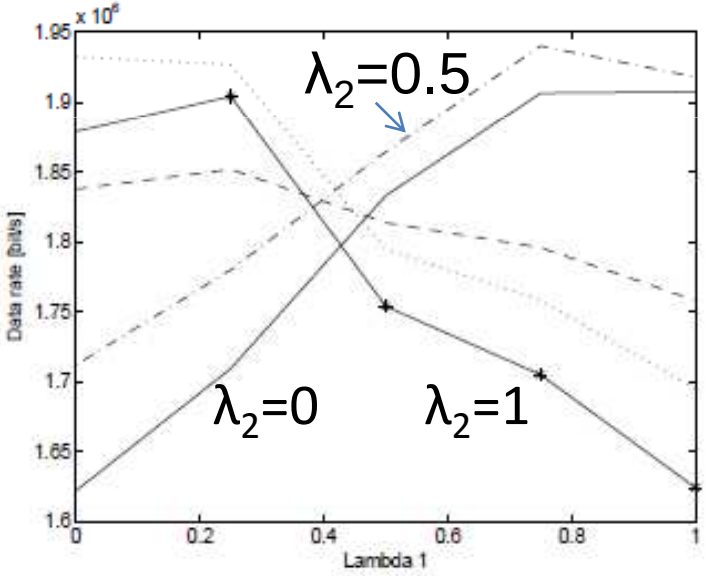
	Attenuation Tx→Rx [dB]				Add. interf. [dBm]
Case	1→1	1→2	2→1	2→2	→1 and →2
1a	60	75	75	60	none
1b	60	75	75	60	-50
1c	60	75	75	60	-65
2a	75	60	60	75	none
2b	75	60	60	75	-50
3a	60	60	75	75	none
3b	60	60	75	75	-50

Results (Case 2a & 2b)

- Low SINR case
- Add. interference none (a) and -50 dBm (b)



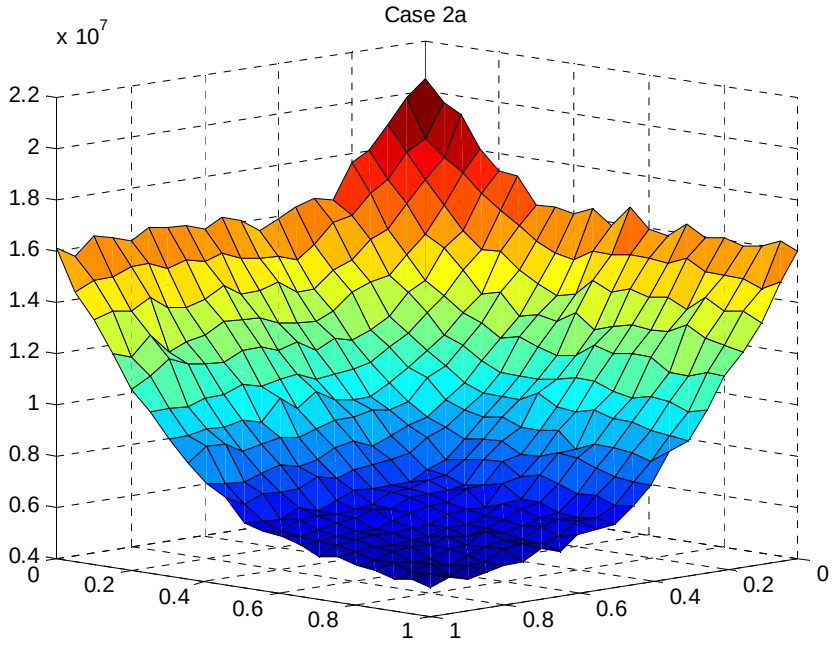
(a) Case 2a

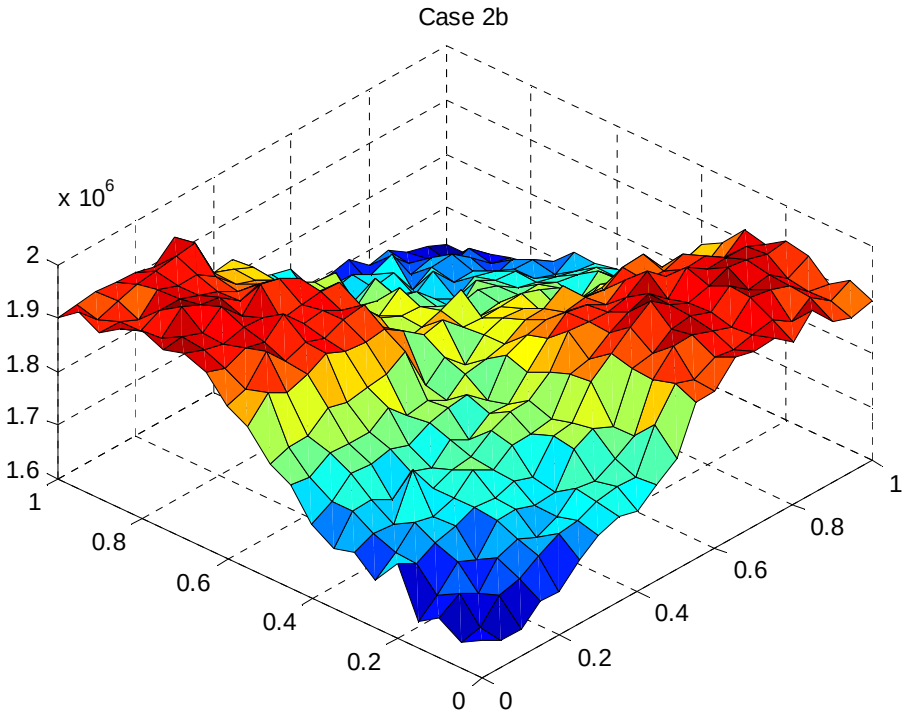


(b) Case 2b

Sumrate

Case 2a vs. 2b

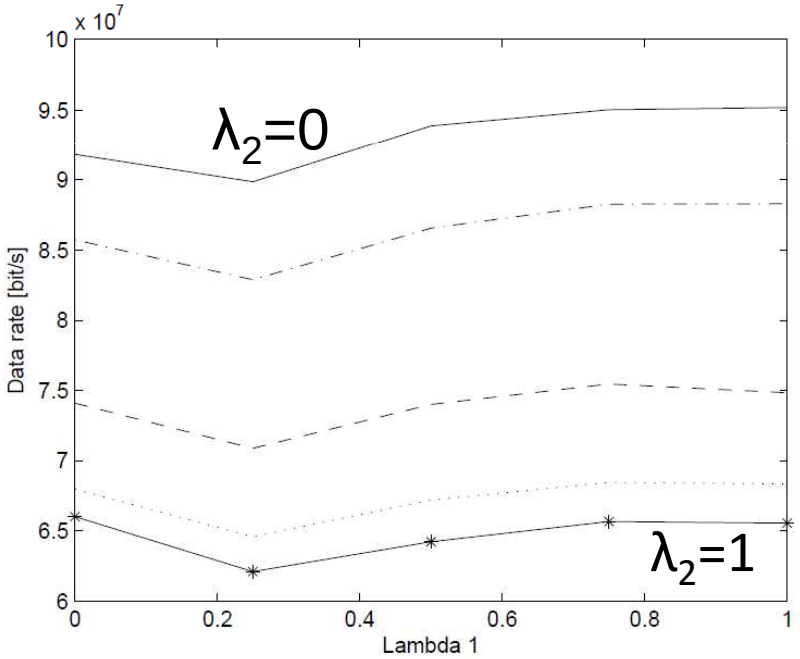




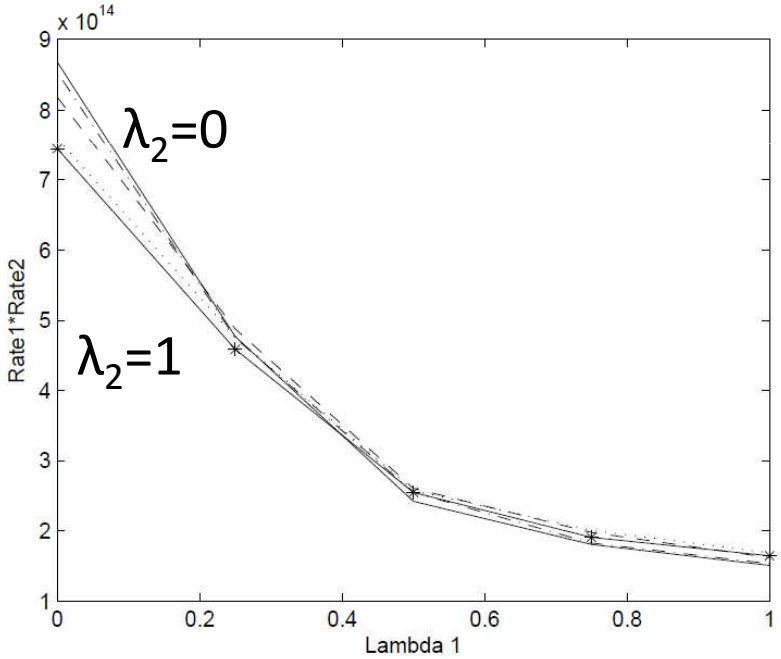
	Attenuation Tx→Rx [dB]				Add. interf. [dBm]
Case	1→1	1→2	2→1	2→2	→1 and →2
1a	60	75	75	60	none
1b	60	75	75	60	-50
1c	60	75	75	60	-65
2a	75	60	60	75	none
2b	75	60	60	75	-50
3a	60	60	75	75	none
3b	60	60	75	75	-50

Results (Case 3a)

- Unbalanced users (User 1: high SINR, User 2:low SINR)
- No additional interference



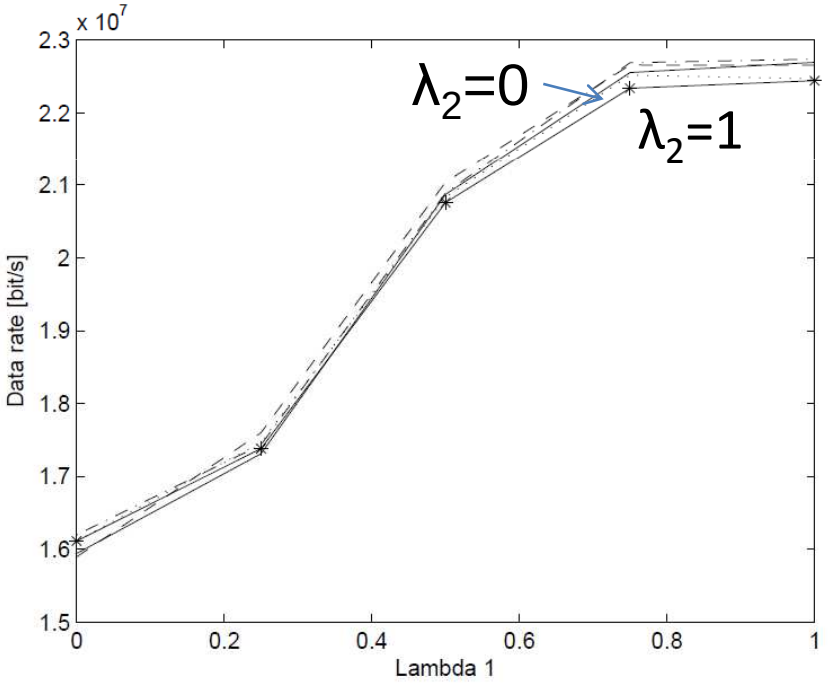
(a) Case 3a: sum rate



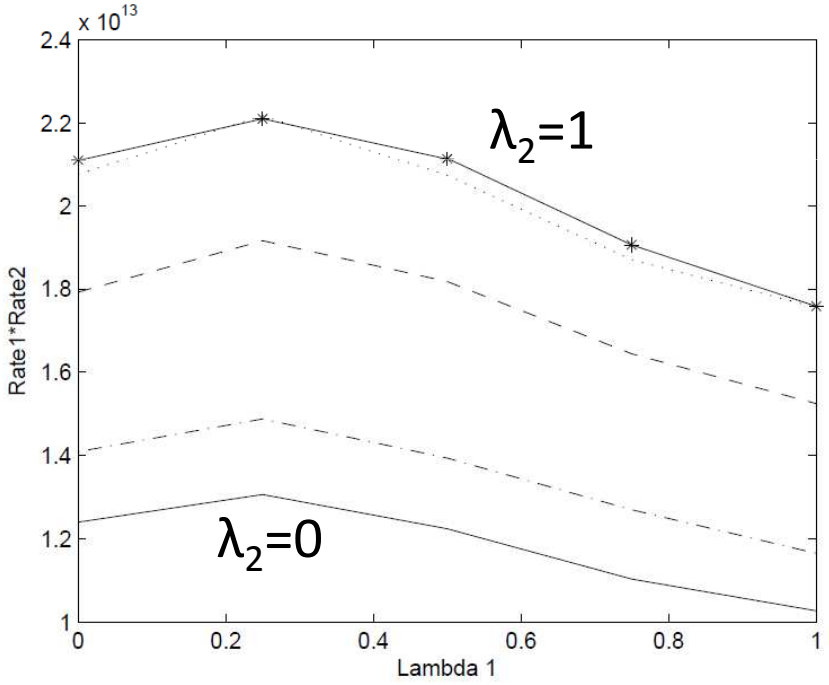
(b) Case 3a: prod. of rates

Results (Case 3b)

- Unbalanced users (User 1: high SINR, User 2:low SINR)
- Additional interference -50 dBm



(a) Case 3b: sum rate



(b) Case 3b: prod. of rates

Conclusions

- Optimal strategy (λ_1 and λ_2) depends on the average SINR of the two users and the background noise-like interference
- Selected fairness criterion greatly affects the ”optimal” strategy
- Future work on the potential gain of the method

	User1		User2		Sum rate		Prod. of rates	
Case	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2	λ_1	λ_2
1a	1	0	0	1	0	0	0	0
1b	1	0	0	1	1	1	1	1
1c	1	0	0	1	0.5	0.5	0.5	0.5
2a	1	0	0	1	0	0	0	0
2b	1	0	0	1	0	0	0	0
3a	1	0	0	1	1	0	0	0.5-1
3b	1	0	0	1	1	0	0	1

λ = 0 = altruistic λ = 1 = egoistic