Inter-Cell Interference Impact on LTE Performance in Urban Scenarios

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(22/11/2013)

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Motivation

- Data traffic is growing exponentially, which forces mobile operators to increase capacity.

- Operators may adopt a universal frequency reuse and deploy increasingly smaller cell sizes, but inter-cell interference becomes higher.

- Hence, a capacity increase should take into account an inter-cell interference reduction, in order to serve a considerable number of users with a relatively high throughput.

Models

- For the inter-cell interference analysis, several models are considered:
  - The allocation of users to sectors is based on the received power (given by the COST-231 Walfisch-Ikegami propagation model).
  - The interfering power takes into account sub-carriers placed in the same frequency as the desired signal.
  - Throughput is considered as a function of SINR and is based on expressions derived in this work.
  - The Resource Blocks (RBs) distribution along the spectrum is contiguous.

LoS Occurrence

- A stochastic assignment of LoS conditions is considered (saturation to 1 is assumed):

$$P_{LoS} = \begin{cases} k \dfrac{h_{b\,[\mathrm{m}]} - H_{B\,[\mathrm{m}]}}{h_{b\,[\mathrm{m}]}} \dfrac{d_{co\,[\mathrm{m}]} - d_{[\mathrm{m}]}}{d_{co\,[\mathrm{m}]}} & , d < d_{co} \wedge h_b \geq H_B \\ 0 & , d \geq d_{co} \wedge h_b < H_B \end{cases}$$

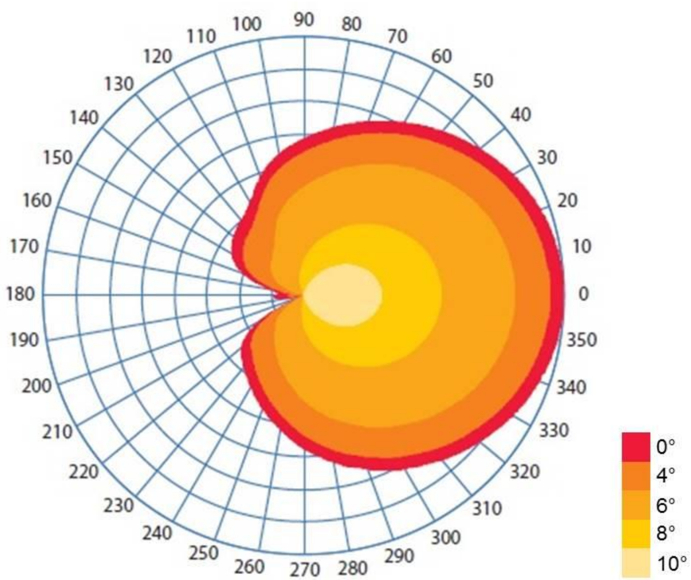
where:

- k: scaling factor (3);
- h_b: height of the antenna;
- H_B: height of the buildings;
- d_{co}: cut-off distance;
- d: distance between the antenna and the user.

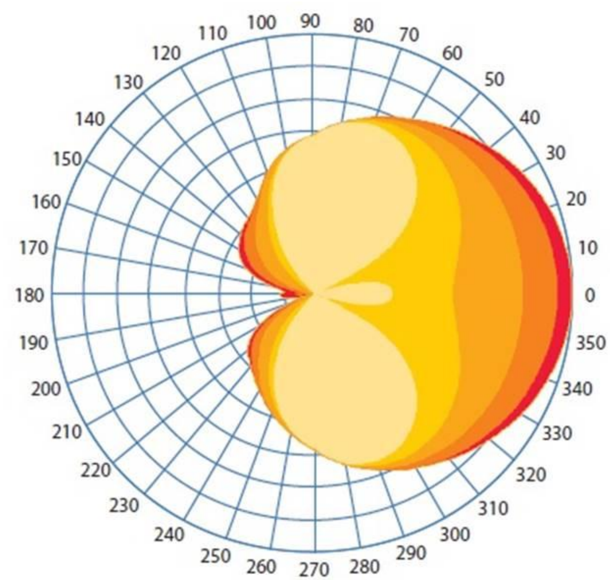
Radiation Pattern

- Both horizontal and vertical radiation patterns are considered. In the latter, the vertical angle depends on whether the user is under LoS conditions or not.
- Electrical and mechanical downtilts are analysed.

Source: Meyer, 2010



Electrical downtilt



Mechanical downtilt

Scenarios (1)

- An analysis of the effect of the antenna's electrical and mechanical downtilts, height, and output power on interference minimisation is performed.
- The following scenarios are analysed in dense urban (centre of Lisbon) and urban (off-centre of Lisbon) environments:

Parameter	800 MHz band	1 800 MHz band	2 600 MHz band
Bandwidth [MHz]	10	15	20
Output power [dBm]	44.8	46.0	46.0
Half-power beamwidth (vertical) [°]	10.3	4.8	3.5

- Category 3 User Equipments with 2×2 MIMO are used.

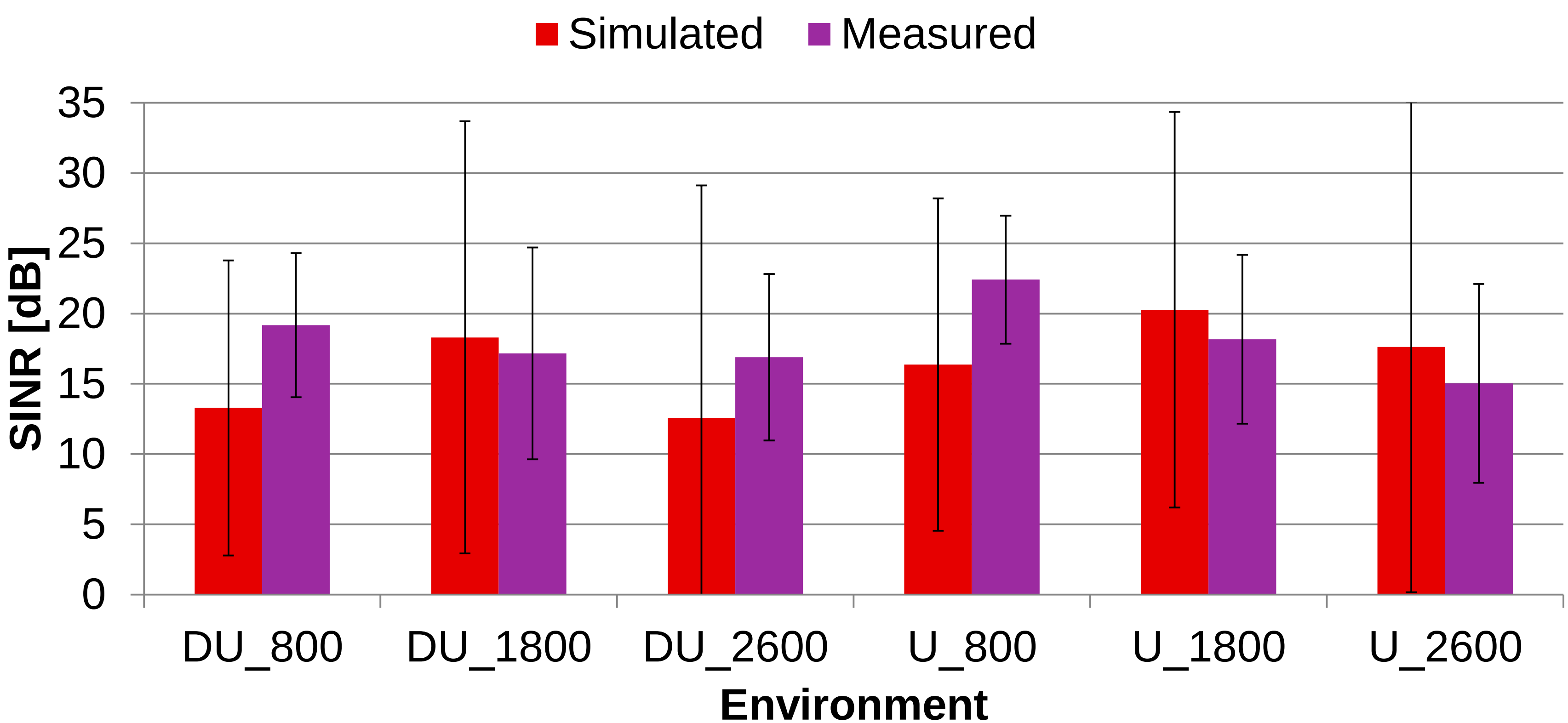
Scenarios (2)

- FTP is the only service considered in the low load scenarios.
- In the high load scenarios analysis, the following traffic mix is considered:

Service	QoS Priority	Minimum throughput [Mbit/s]	Maximum throughput [Mbit/s]	Penetration [%]
Video streaming	1	1.024	8	40
Chat	2	0.064	0.384	5
Web browsing	3	1.024	100	24
FTP	4	1.024	100	9
E-mail	5	1.024	100	5
P2P	6	1.024	100	17

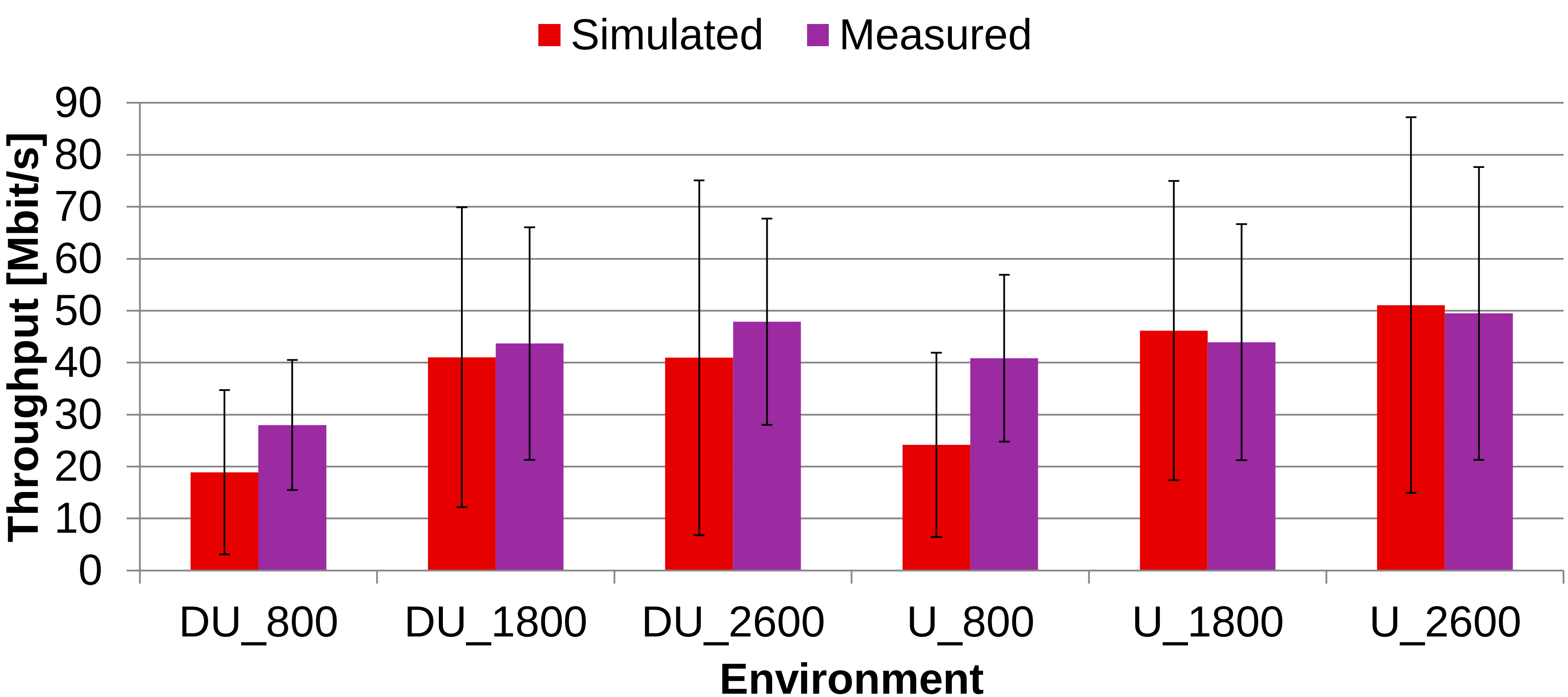
Low Load Scenarios (1)

- Simulations show that interference is not negligible in the 800 MHz band.



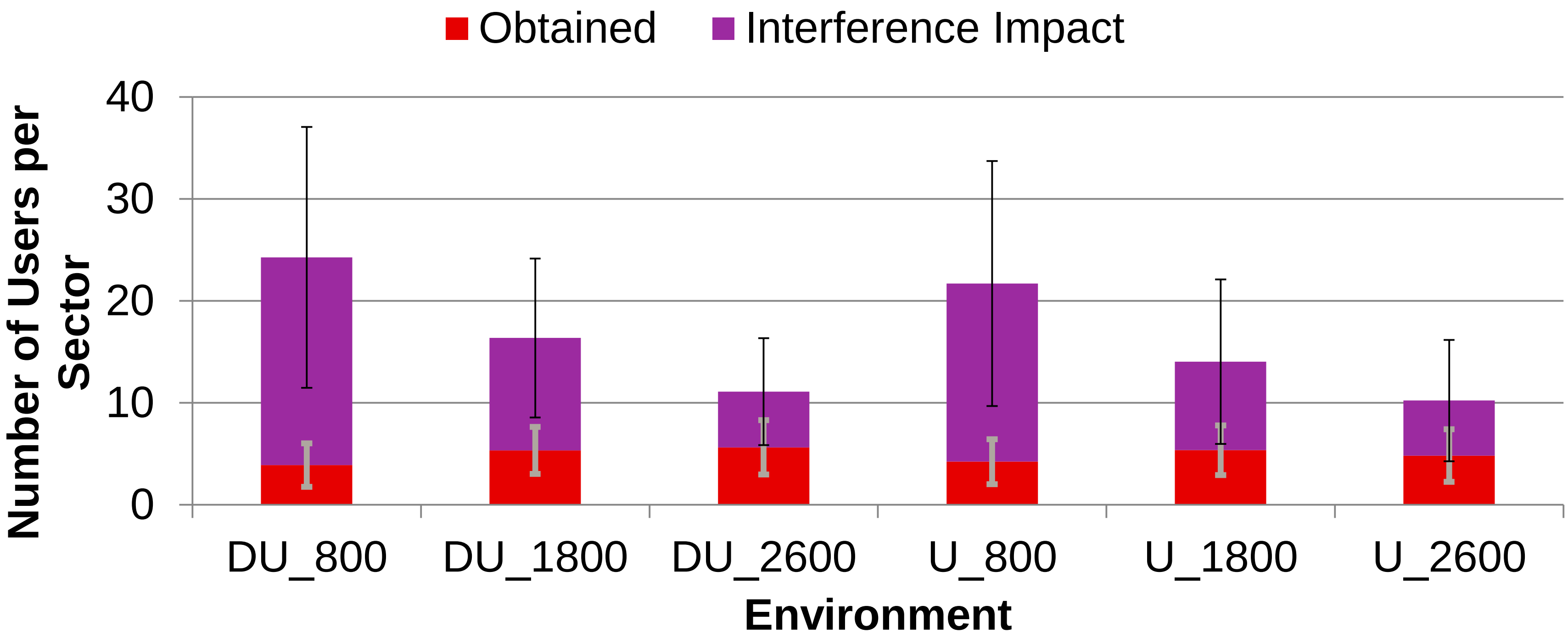
Low Load Scenarios (2)

- In the simulations, sharing of RBs among users was more frequent than in measurements.



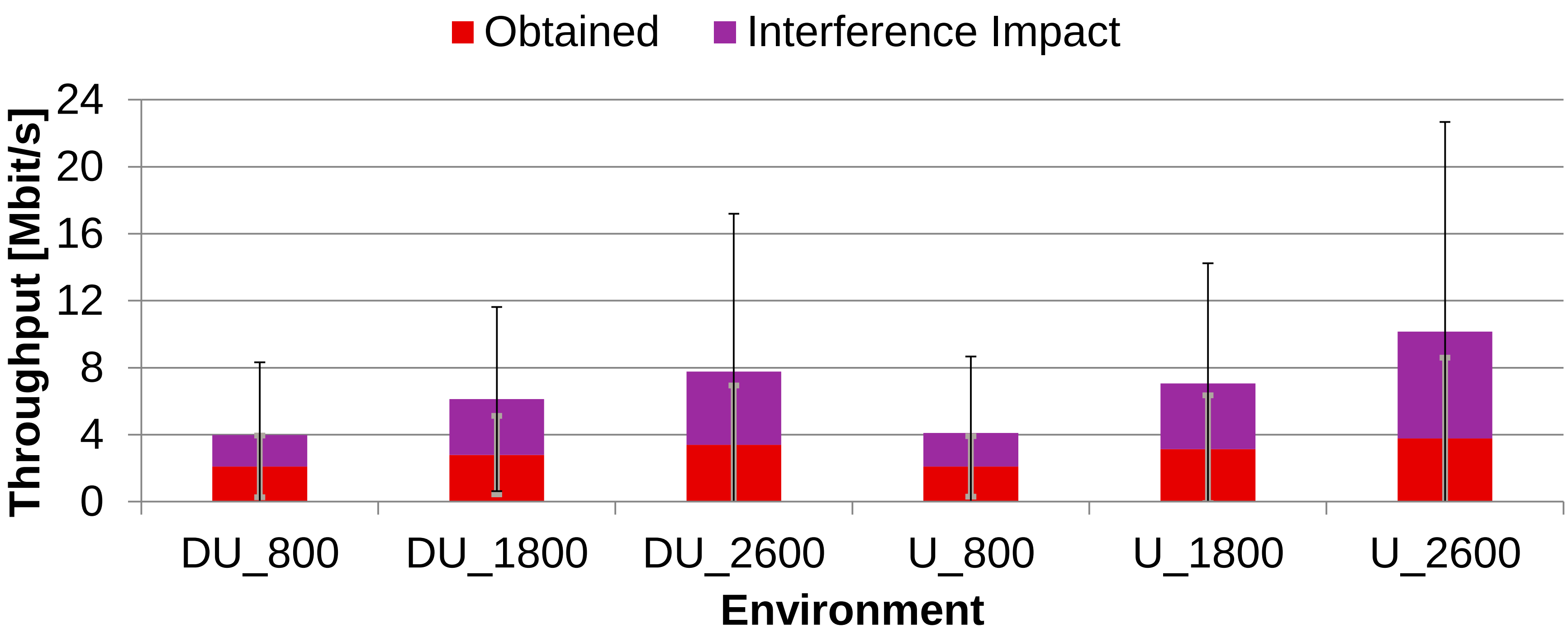
High Load Scenarios (1)

- When interference is neglected, the lower the frequency band the higher the number of users served, because of a higher sector antenna's range.



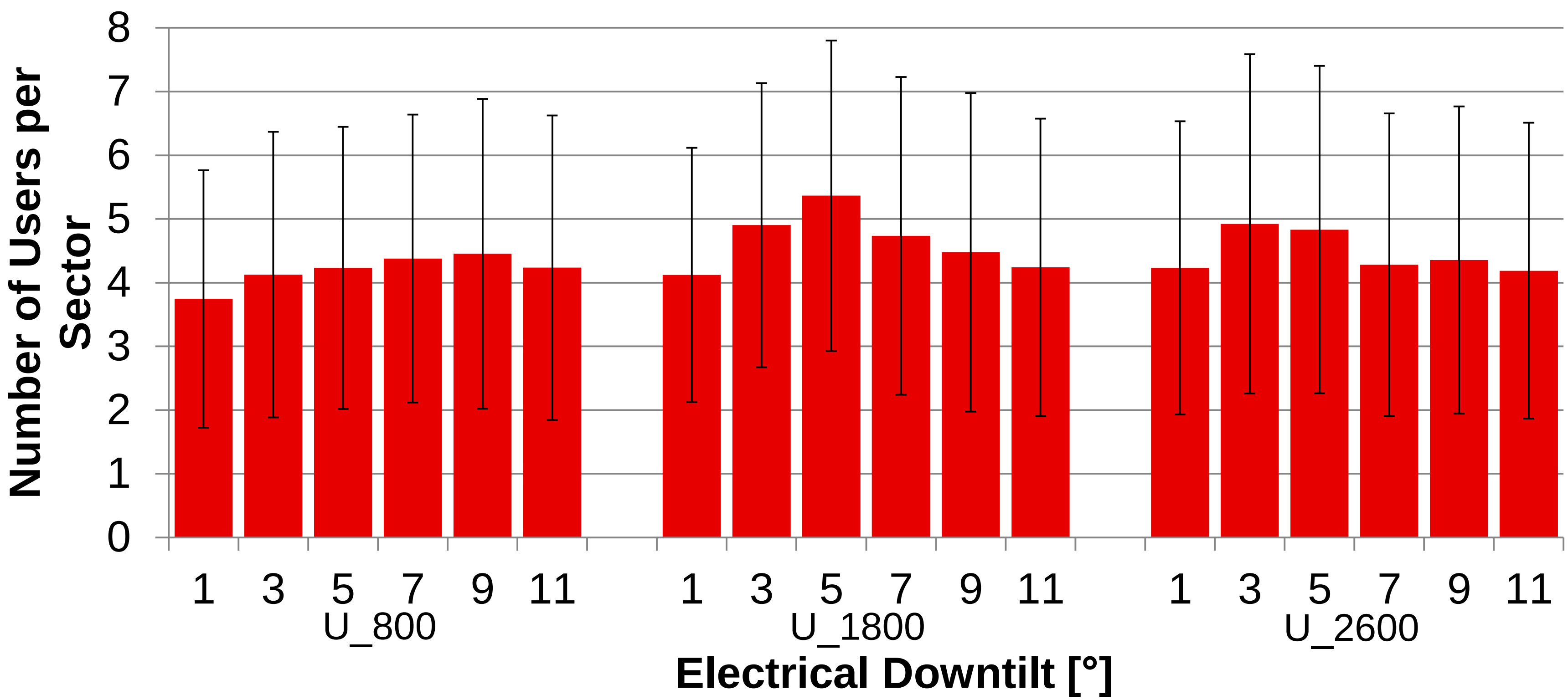
High Load Scenarios (2)

- Relatively high standard deviations are due to users in either LoS or NLoS conditions at different distances from the antennas and requesting different services.



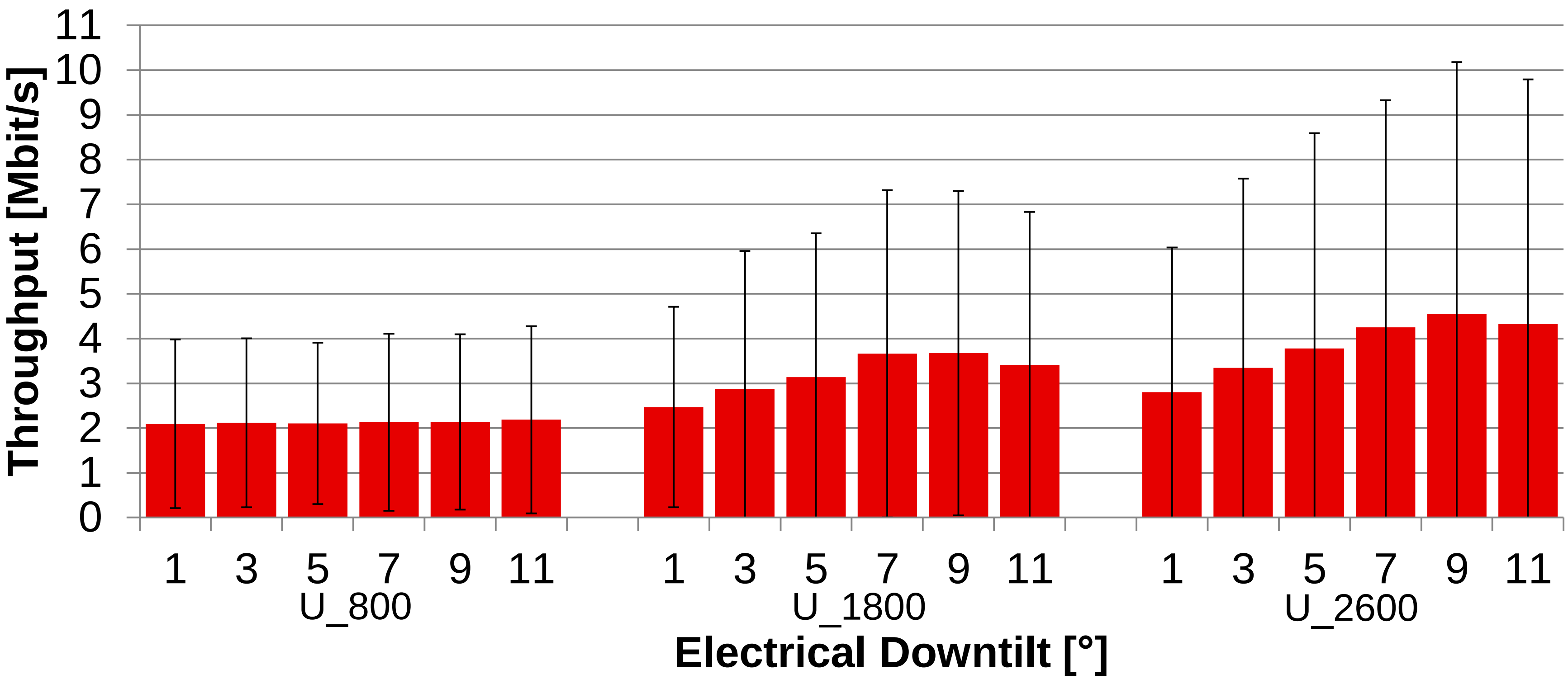
Electrical Downtilt (1)

- The higher the frequency band the lower is the optimal downtilt, which can be explained by a decreasing vertical half-power beamwidth.



Electrical Downtilt (2)

- For the off-centre, 11°, 9° and 9° of electrical downtilt enhance throughput for the 800, 1 800 and 2 600 MHz bands, respectively, by 4.3%, 17.2% and 20.4%.



Results

- The highest improvements on the number of served users happen for a transmitter output power of 10 W for the 1 800 MHz band on both the centre (11.6% improvement) and off-centre (6.9% improvement).

- The maximum throughput enhancements occur for an electrical downtilt of 11° for the 1 800 (27.3% improvement) and 2 600 MHz (18.9% improvement) in the centre, and 9° for the 1 800 (17.2% improvement) and 2 600 MHz (20.4% improvement) in the off-centre.

Conclusions

- In this work, an evaluation of LTE performance in urban scenarios concerning inter-cell interference via antenna aspects was performed.
- A stochastic generation of LoS occurrences, a contiguous spectrum allocation, the radiation pattern of the antennas and a received power based association of users to sectors was considered in a program intended to simulate a real network as close as possible.
- It was found that output power and electrical downtilt provide the best improvements on the number of users served per sector and user’s throughput, respectively.

Questions

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