Carleton UNIVERSITY

On the Impact of Correlated Shadowing on the Performance of User-in-the-Loop for Mobility

Tamer Beitelmal, Rainer Schoenen, Halim Yanikomeroglu

tamer@sce.carleton.ca, rs@sce.carleton.ca
tamer@sce.carleton.ca

http://userintheloop.org/

SCE, Carleton University, Ottawa, Canada – Prof. Yanikomeroglu

Outline

- Introduction

- User in the loop (UIL)

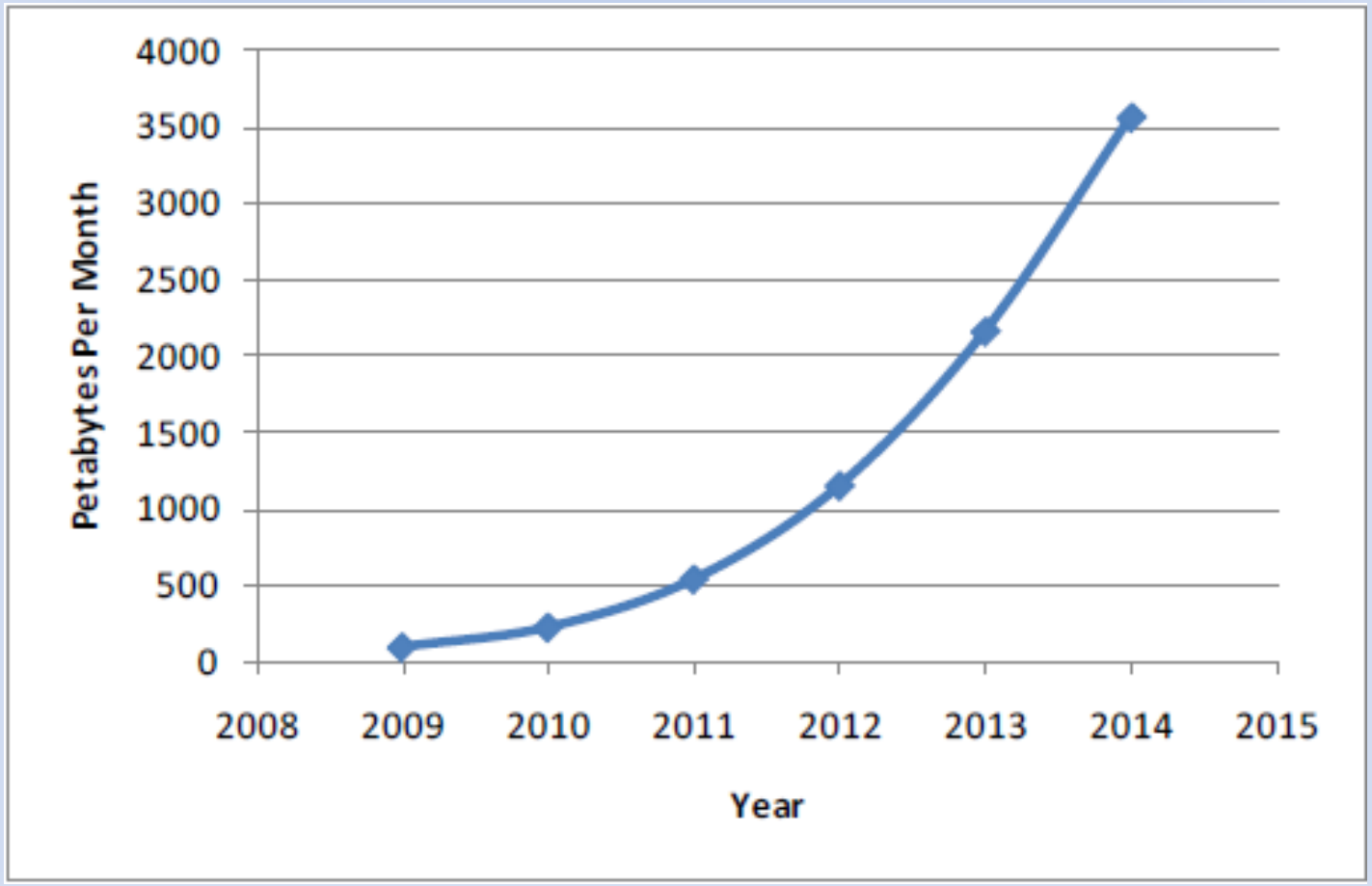
- Correlated Shadowing

- Simulation results

- Conclusion

Introduction

- The cellular network users are demanding more traffic and expecting a ubiquitous high data rate.



Cisco Global Mobile Broadband Data Projection

Introduction

- Several techniques are investigated to cope with this massive demand.
-All the current solutions are focusing on improving this issue from the supply side. The existing techniques are reaching their theoretical limit.
- It is expected that a significant improvement on the system performance can be gained if the end users become a part of the system and not just consumers.

A new user-centric paradigm should be considered to motivate users to be an element of the system and not just consumers.

Introduction

The currently existing ideas are:

- Expand capacity per cell
  - Optimize the radio network: potential in PHY+MAC layer
  - Sectorization
- Roll out new generations faster (4G, 5G)
- Buy more spectrum
- Offload data to WiFi and femtocells
-Deploy metropolitan picocells or mesh networks

MORE POWER
LESS GREEN
MORE CAPEX
MORE OPEX

.
.
Etc.

-[Source: 10 ways to deal with mobile data capacity crunch – www.amdocs.com]

New impulses:

- Where is the user in this picture? *(The need for a user-centric approach)*
- Why do we spend so much effort and money on the supply side (4G,5G) if the average user is not willing to pay more per month?

User in the Loop

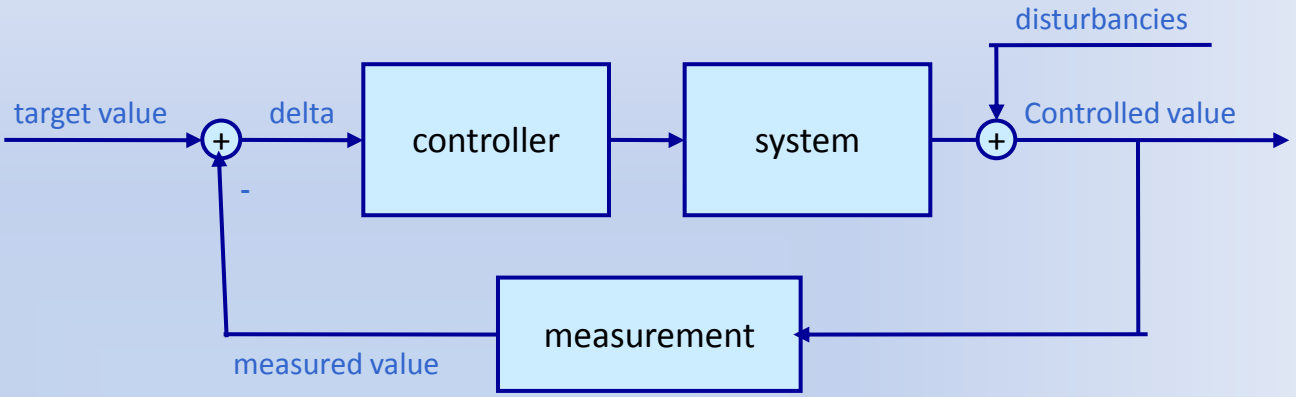
UIL is a user-centric approach that offers an incentive to influence users' behavior to participate in the system improvement process.

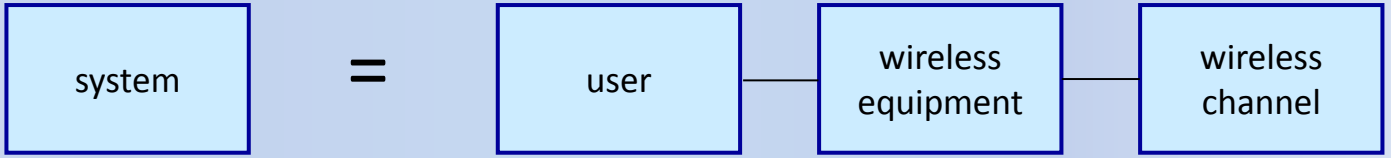
The user-in-the-loop (UIL) spatial approach provides a solution to fulfil the increasing traffic demand by convincing users to move to locations with higher SINR values.

By moving a walkable distance, the cell saves some resources that can be used to serve other users or to provide higher data rates for current
users.

User in the Loop

An approach to control the users' behavior is needed to cope with the high traffic demand.





controller

=

Mobility or tariff control

user-friendly display of suggestion

To facilitate the moving decision for the user, the authors in [5] and [8] suggested that the UT device should have an indicator for the better spectral efficiency locations plus an option to display a map to guide the user to reach the destination.

User in the Loop

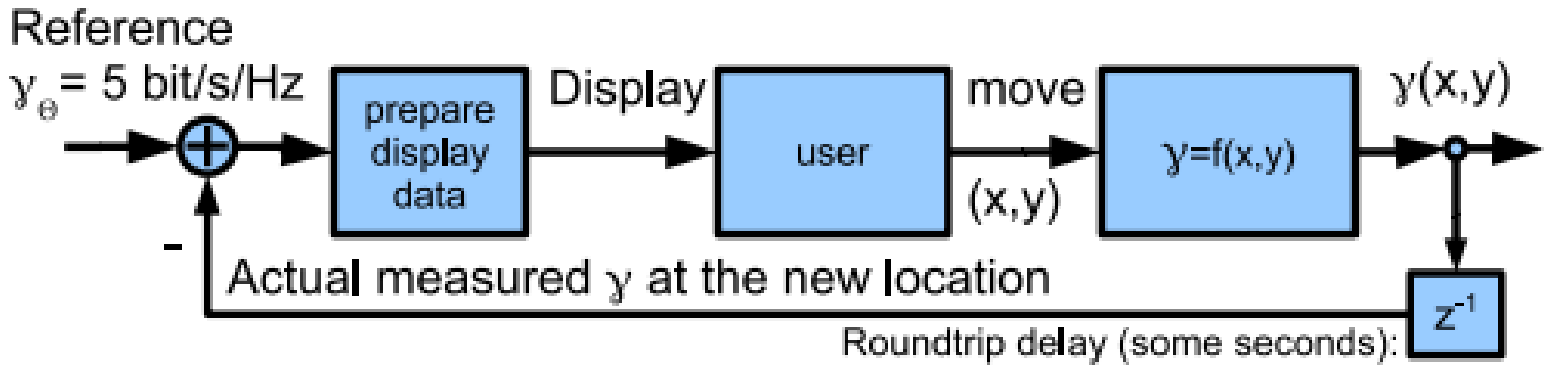


Fig. 1. The user becomes a part of the system (in the loop) [5].

The cooperation from users will provide advantages for the operators because fewer RBs are assigned to users in high SINR locations, consequently they can save resources to better serve current users or accommodate new users.

Correlated shadowing model

In this work, the correlated shadowing effect was studied to test the UIL under a more realistic scenario.

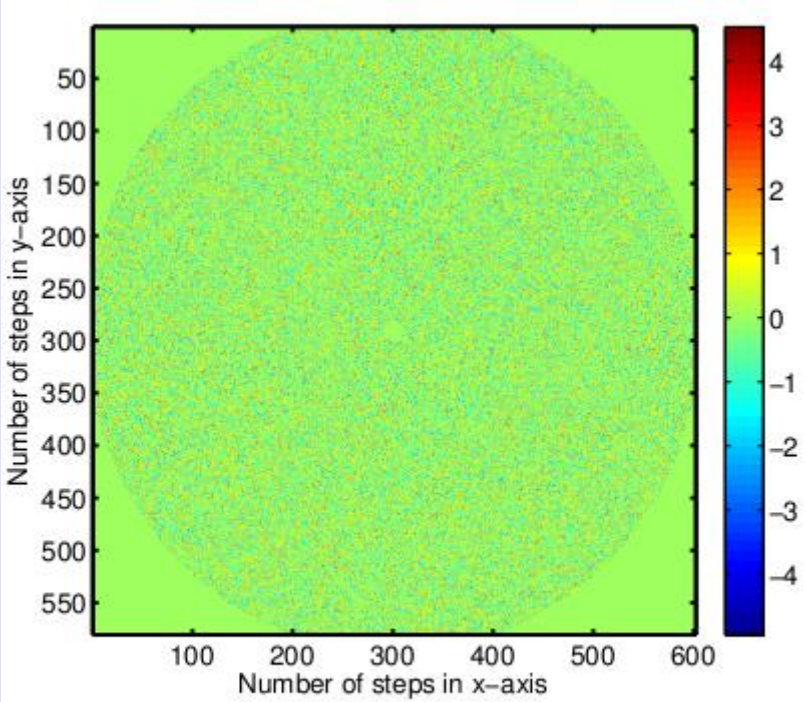
UIL approach is based on the user movement, therefore using the correct shadowing model is vital in calculating the moving distance and the resulting spectral efficiency.

Model Description:

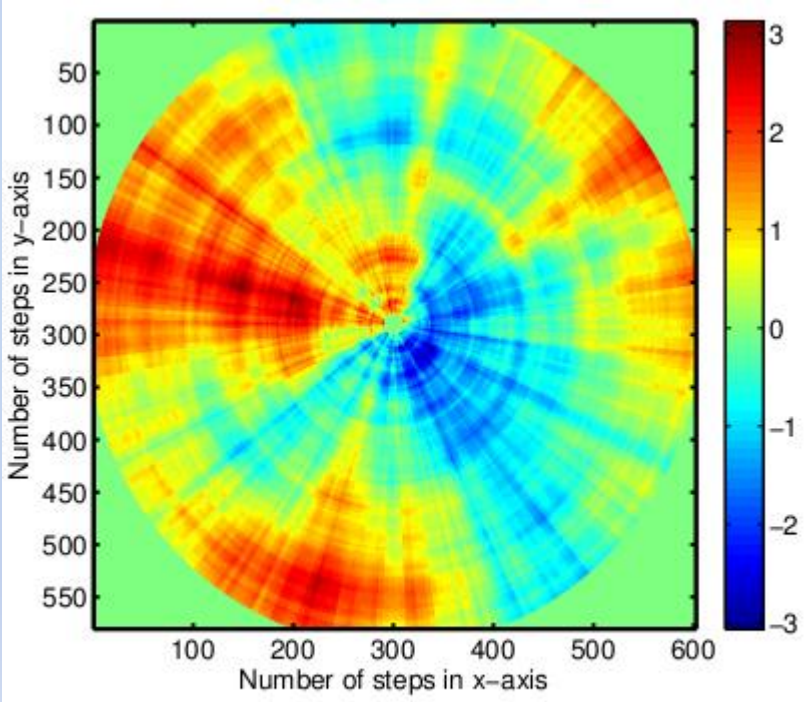
If two UTs are located at the same point then they are 100% correlated. This correlation ratio decreases as the distance ratio and/or the angle between the UTs increases. After certain values ($\phi 0$ /R0), the two UTs are considered to be totally uncorrelated.

Correlated shadowing model

This independence in shadowing values is an ideal assumption and it will affect the accuracy of the simulation results especially when the number of transmitters/receivers increases.



. Example of two-dimensional uncorrelated shadowing field



. Example of two-dimensional correlated shadowing field.

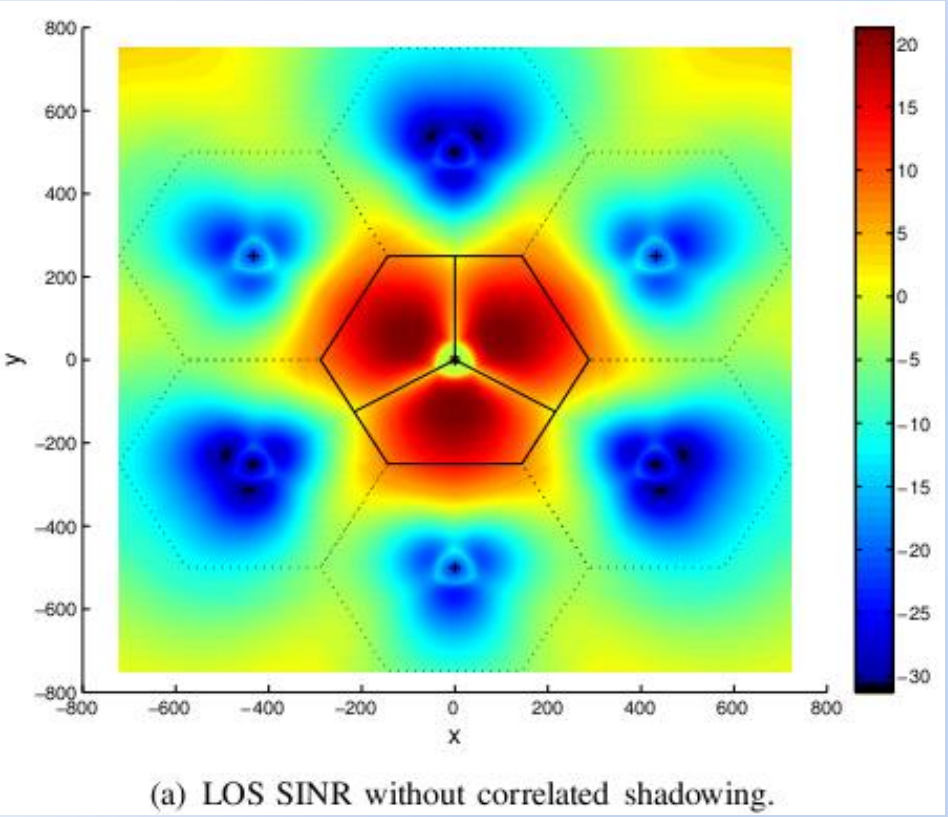
Simulation Results

The model analysis is done by calculating the cell spectral efficiency before and after applying the UIL mobility.

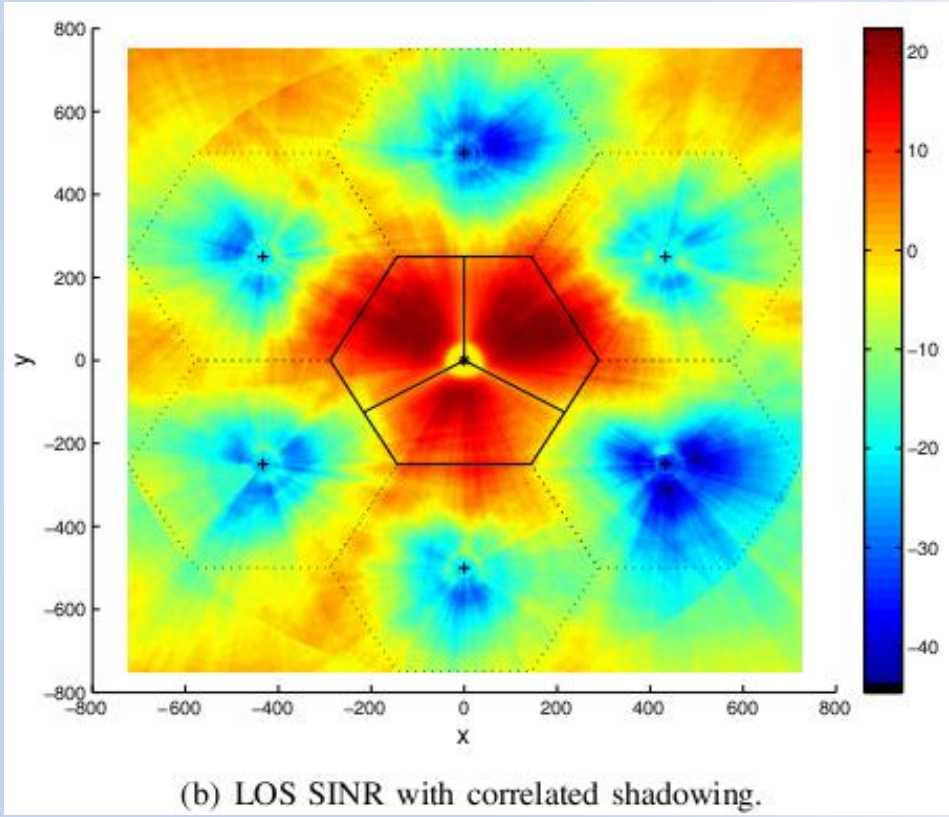
Although the SINR distribution is different in the two cases, the average spectral efficiency is the same.

The moving distance depends on the correlation parameters : $\phi 0$ and R0.

Simulation Results



(a) LOS SINR without correlated shadowing.



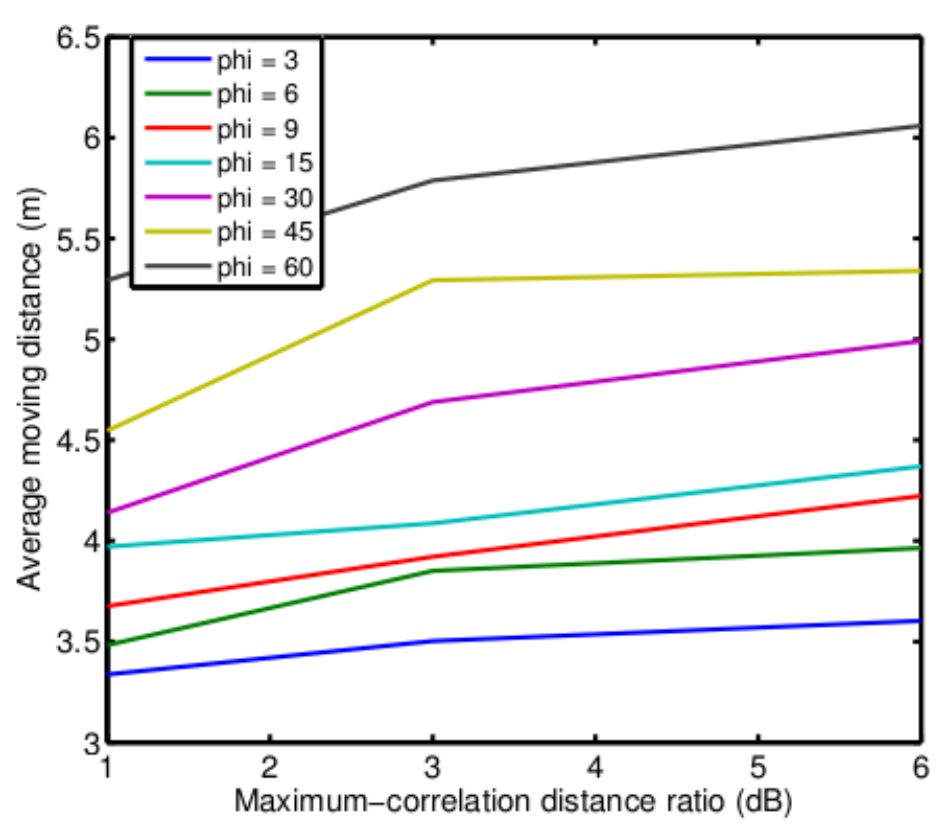
(b) LOS SINR with correlated shadowing.

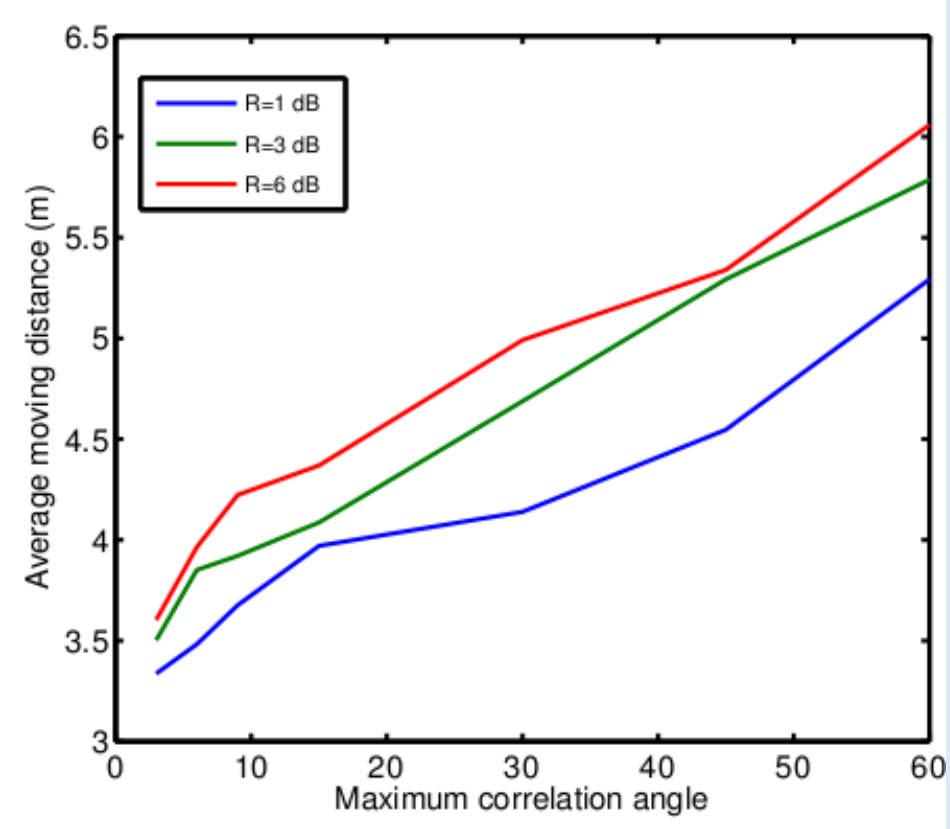
Simulation Results

TABLE IV
CELL-AVERAGE SPECTRAL EFFICIENCY RESULTS FOR THE UMa SCENARIO EVALUATION [b/s/Hz/Sector] WITH $p_M = 0.5$ AND $\gamma_\Theta = 2.5$ b/s/Hz.

Scenario	γ [b/s/Hz] without UIL	γ [b/s/Hz] with UIL	Average moving distance [m]
No shadowing effect	1.254	1.974	4.7
Uncorrelated shadowing model	1.225	2.028	2.69
Correlated shadowing $R_0 = 1$ dB, $\phi_0 = 3°$	1.227	2.041	3.34
Correlated shadowing $R_0 = 3$ dB, $\phi_0 = 30°$	1.234	2.016	4.69
Correlated shadowing $R_0 = 6$ dB, $\phi_0 = 60°$	1.220	2.005	6.06

Simulation Results





Simulation Results

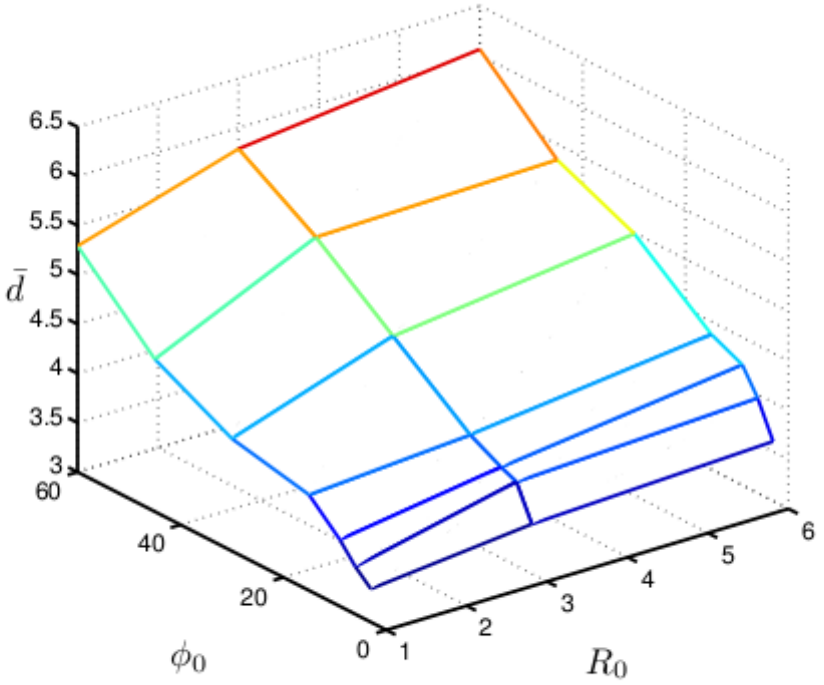
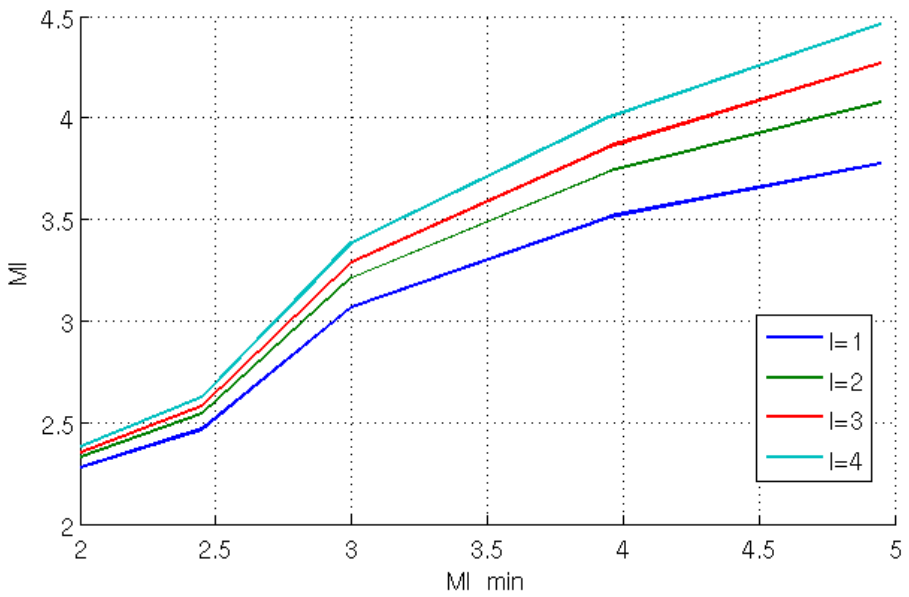


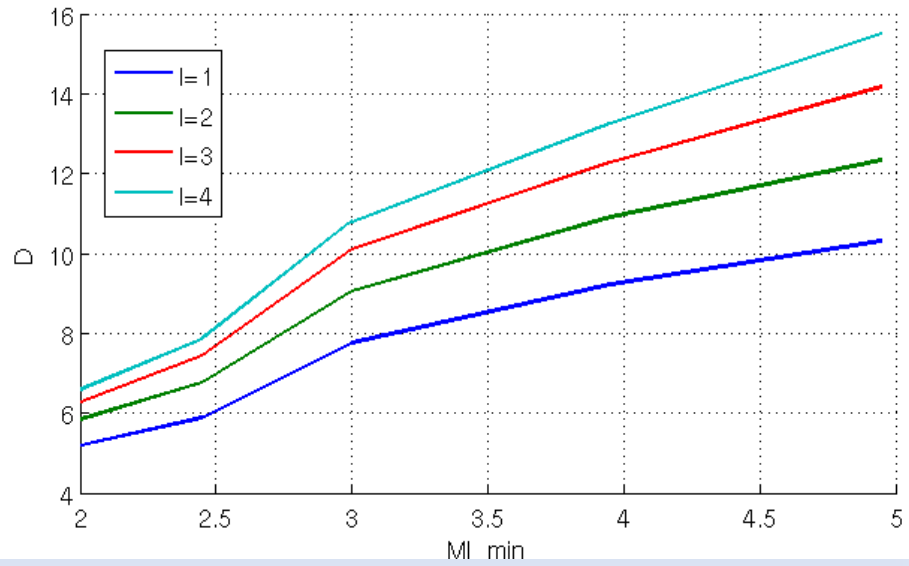
Fig. 7. A 3-D presentation of the relation between the maximum correlation (angle ϕ_0 and distance ratio R_0) and the average moving distance $\bar{d}$.

Simulation Results

IMT-A-Scenario Uma Discount incentive

Survey 2011: Spectral Efficiency Results with Spatial UIL





Conclusion

-The massive growth of data traffic in cellular network requires a paradigm shift to be more user-centric.

-The UIL approach is a user-centric approach based on convincing users to be part of the system by providing them some incentive.

-Users can cooperate by moving to higher SINR locations.

Conclusion

-This user cooperation can lead to a significant increase in the cell spectral efficiency with no change to the current cellular system as shown in the UIL literature.

-Analyzing the UIL approach under a more realistic scenario(by including the correlated shadowing) resulted the same improvement on the spectral efficiency. However the change on the moving distance is in the same order of magnitude.

- In a parallel work, a survey was conducted to understand the user behavior in relation to different class of incentives [16]. For more accurate results, the pM values suggested in [16] can be used instead of 0.5 used in this paper.