

# Quality of Service and Bandwidth Management Issues in Wireless Networks with Mobile Hosts

**Dr. Peppino Fazio**  
University of Calabria, Italy

Part 3

# Mobility Analysis and Prediction

How to evaluate the CST - simulation campaigns

The number of cells that a user will probably visit can be evaluated as follows:

$$C_p = \left[ \frac{T_{CHT}}{T_{CST}} \right]$$

$f(x) = \frac{1}{\mu} e^{-\frac{x}{\mu}}$   
Exponential distribution  
(from literature)

$f(x) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$   
Gaussian distribution

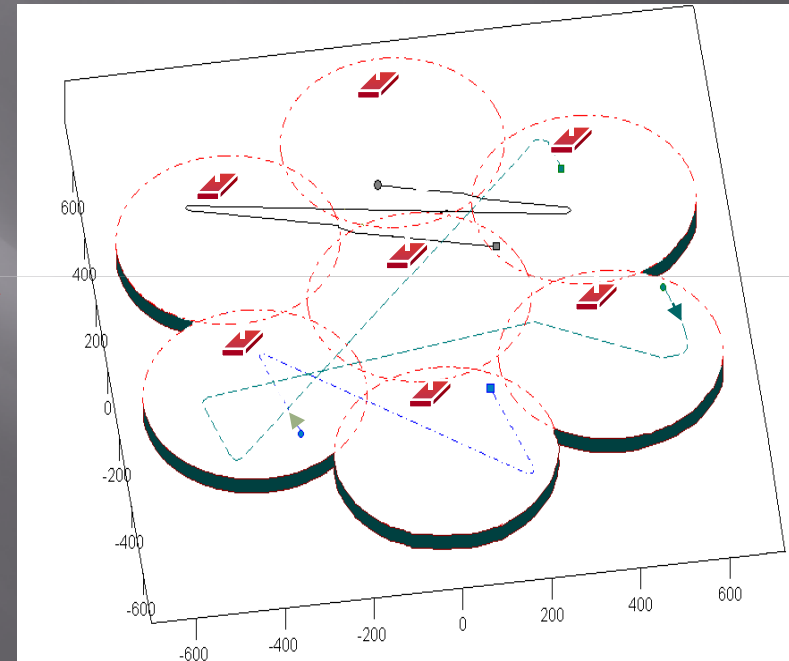
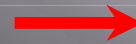
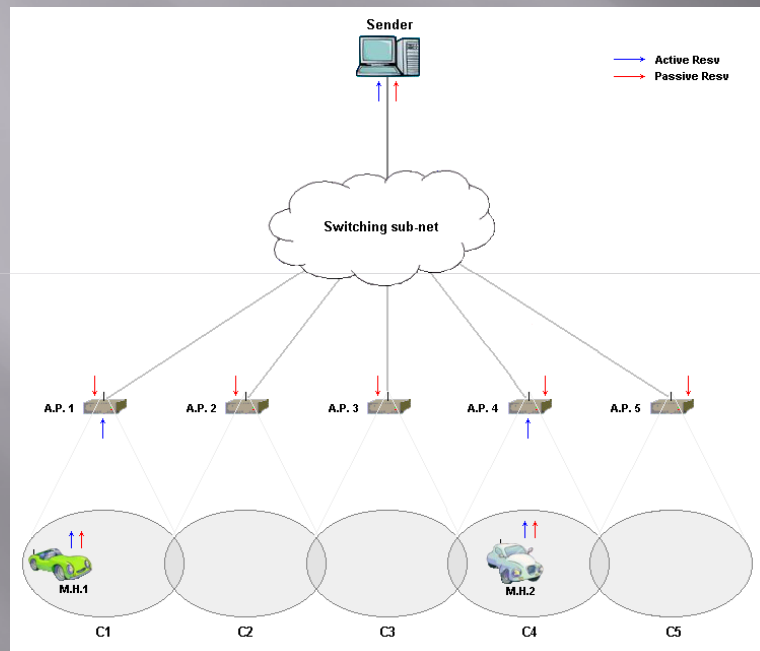
The value of  $C_p$  is used only for a quantitative purpose and the assumption of a CST normally distributed has been verified through a KS-test.

**WHAT ABOUT 2D ENVIRONMENT?**

# Mobility Analysis and Prediction

## From 1D to 2D

Let us now consider real scenarios (2D):

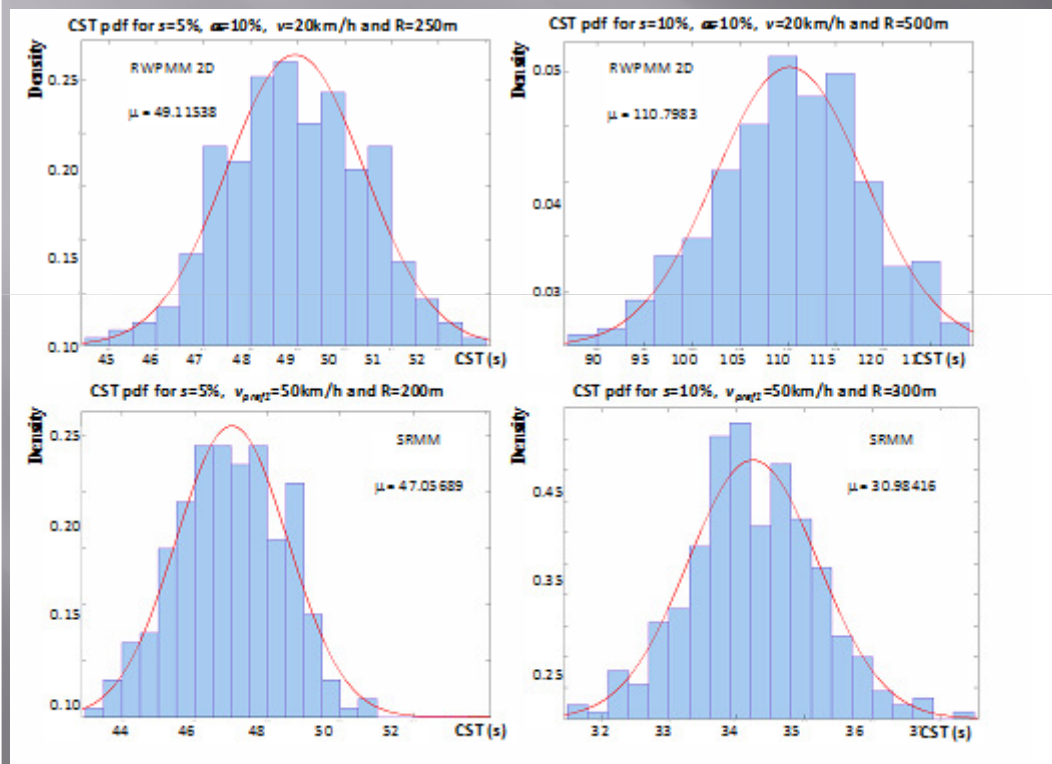


Are there new issues?

# Mobility Analysis and Prediction

## From 1D to 2D

Other simulation campaigns have been carried out in order to evaluate **CST** distribution.



The same considerations of the previous case (1D) can be made for 2D models (like RWP and SR). The hypothesis of Gaussian distribution is still valid.

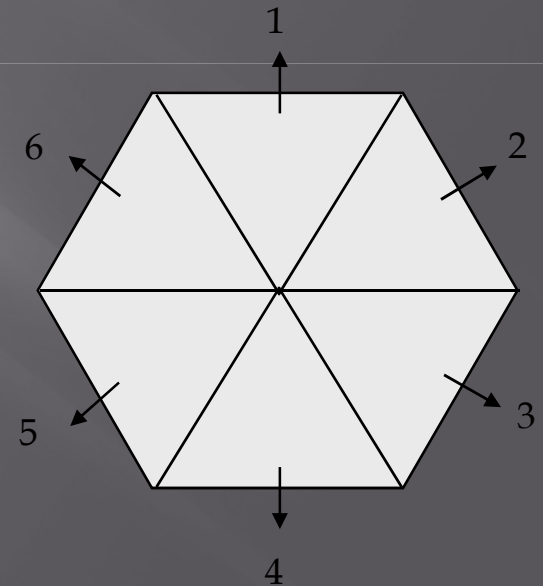
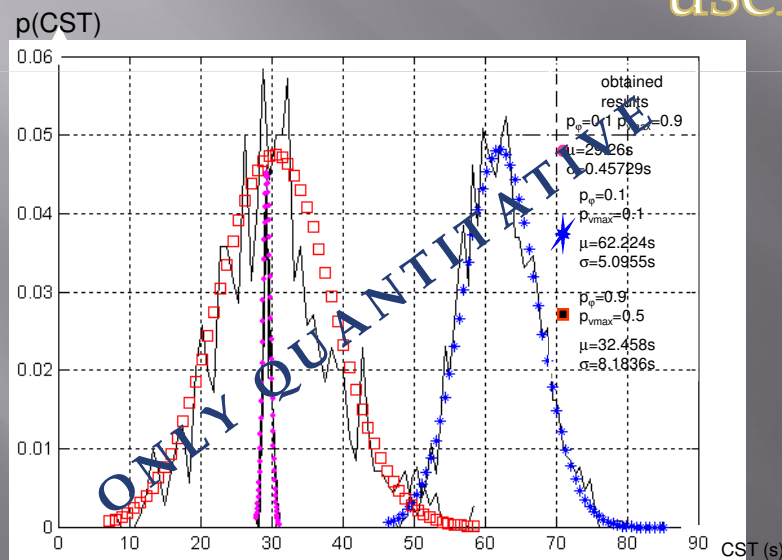
## What is the new issue?



# Mobility Analysis and Prediction

## From 1D to 2D

The CST knowledge is not enough for users description in a 2D environment, because it gives **only a quantitative** knowledge of the number of cells that a user will visit.

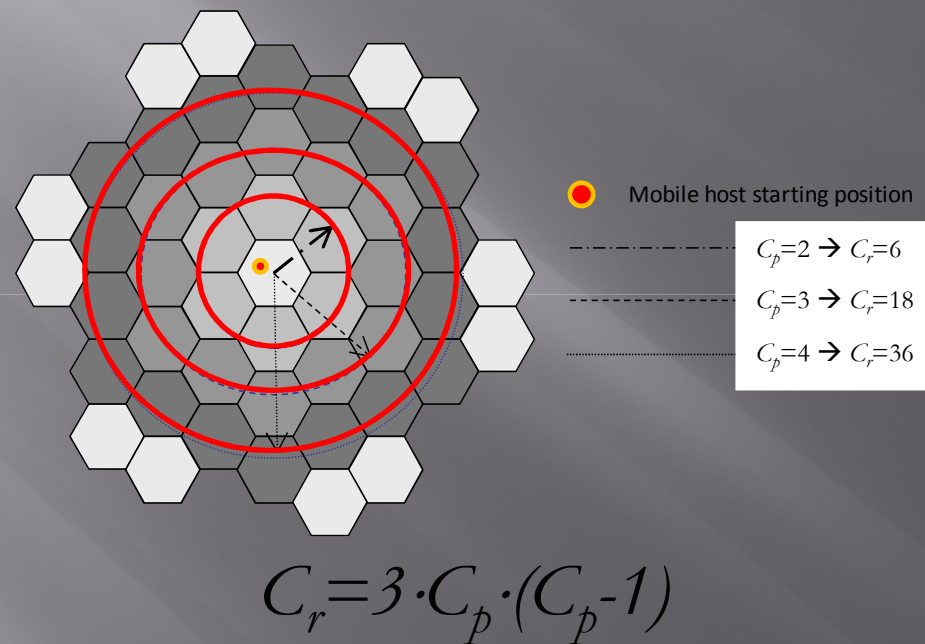


The possibly preferred movement directions of users must be taken into account, so a **qualitative** analysis becomes feasible.

# Mobility Analysis and Prediction

## From 1D to 2D

WHY QUALITATIVE ANALYSIS IS NEEDED IN 2D?



The number of cells on which the reservations must be made increases in polynomial way, following the illustrated rule: the bandwidth wastage is not negligible (for  $C_p=5$  we have  $C_r=60!!!$ ).



# Mobility Analysis and Prediction

## DIRECTIONAL ANALYSIS IN 2D SCENARIOS

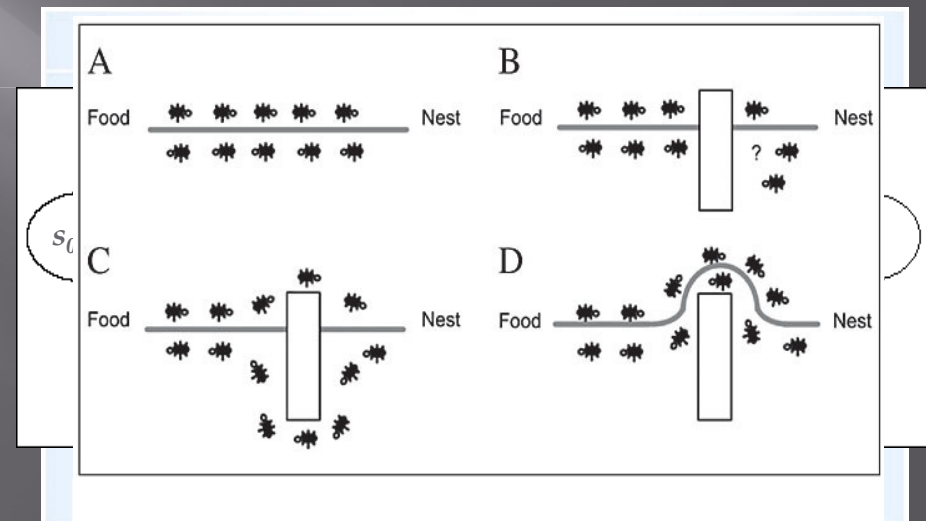
There are many works in literature which use many “tools” to account for directional behaviors:

NEURAL NETWORKS

MARKOV CHAINS

SWARM

INTELLIGENCE

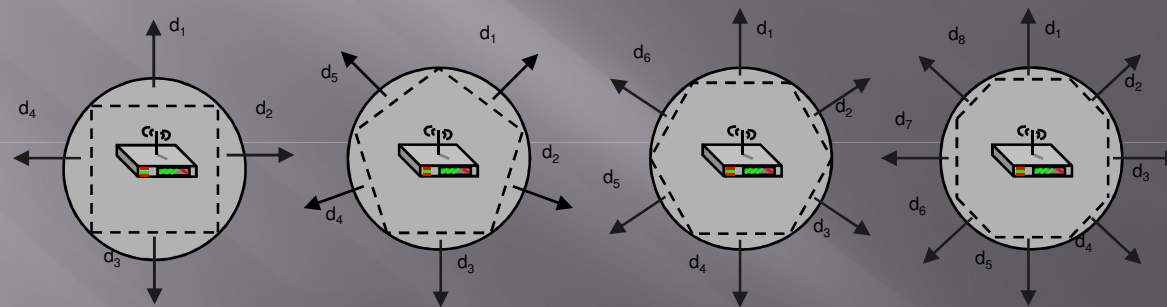




# Mobility Analysis and Prediction

## A PRACTICAL EXAMPLE

Coverage areas can be approximated through n-side regular polygons and n directions can be considered:



Then a  $n \times n$  matrix can be considered, where the rows indicate the hand-in directions and the columns the hand-out directions; the elements are defined as:

$$M(x,y) = p_{x,y} = p_{cMIP}(x,y) = p(out\ to\ y \in S_{bo}\ t=t_0 + CST / in\ from\ x \in S_{bo}\ t=t_0)$$



# Mobility Analysis and Prediction

## A PRACTICAL EXAMPLE (n=6)

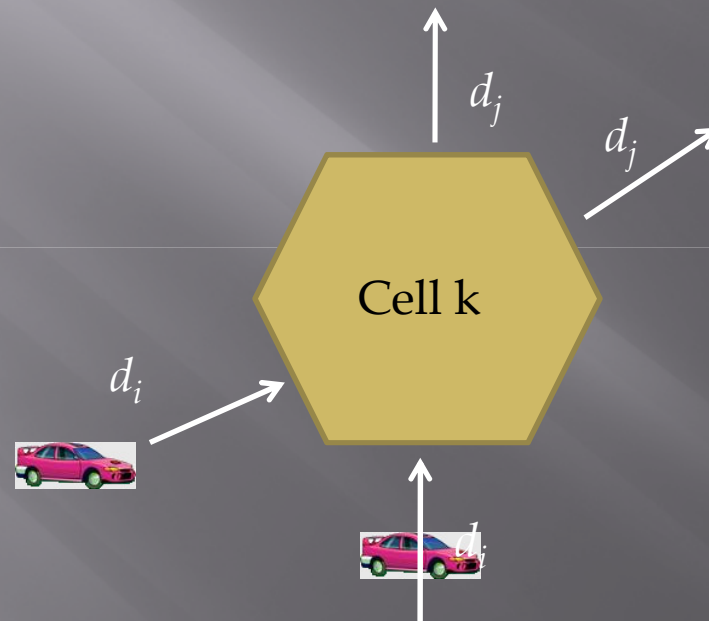
How the elements of the matrix  $M$  can be obtained?



# Mobility Analysis and Prediction

## A PRACTICAL EXAMPLE (n=6)

How the elements of the matrix  $M$  can be obtained?



$$M_k(i, j) = \frac{\text{Number\_of\_handins\_from\_}d_i\_\text{and\_handout\_to\_}d_j}{\text{Number\_of\_total\_handins\_from\_}d_i}$$

All the elements are averaged on the number of mobile host

# Mobility Analysis and Prediction

## A PRACTICAL EXAMPLE (n=6)



	1	2	3	4	5	6
1	0.0137	0.0244	0.2779	0.3663	0.3034	0.0256
2	0.0325	0.0132	0.0399	0.3700	0.5056	0.0549
3	0.3708	0.0430	0.0125	0.0316	0.0521	0.5054
4	0.3692	0.2798	0.0249	0.0129	0.0248	0.2994
5	0.3743	0.5094	0.0440	0.0328	0.0127	0.0437
6	0.0318	0.0426	0.5094	0.3769	0.0427	0.0145



$$M(5,2)=0.5094$$

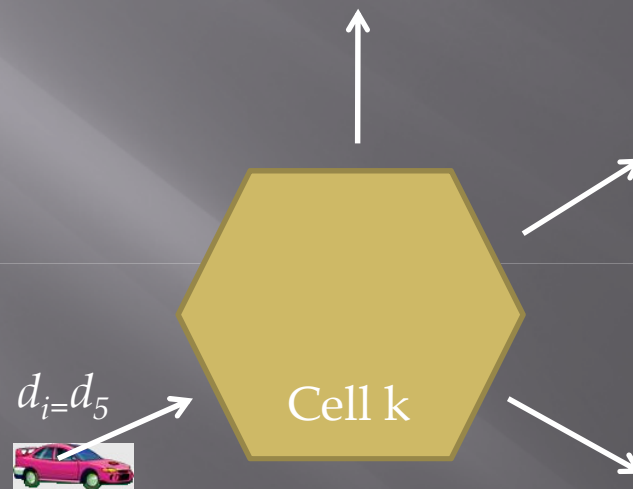
All the elements are averaged on the number of mobile host

# Mobility Analysis and Prediction

## A PRACTICAL EXAMPLE (n=6)

### HOW TO USE THE MATRIX

	1	2	3	4	5	6
1	0.0137	0.0244	0.2779	0.3663	0.3034	0.0256
2	0.0325	0.0132	0.0399	0.3700	0.5056	0.0549
3	0.3708	0.0430	0.0125	0.0316	0.0521	0.5054
4	0.3692	0.2798	0.0249	0.0129	0.0248	0.2994
5	0.3743	0.5094	0.0440	0.0328	0.0127	0.0437
6	0.0318	0.0426	0.5094	0.3769	0.0427	0.0145



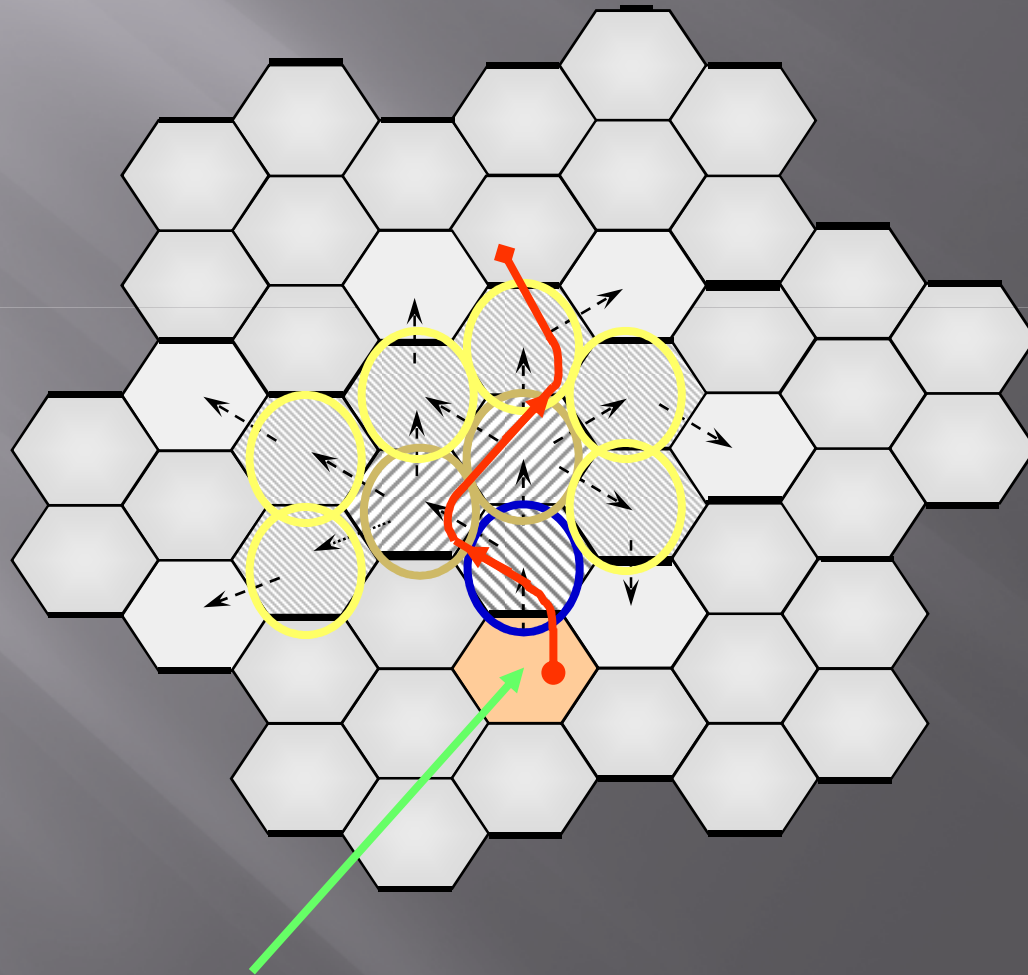
HOW MANY NEIGHBORS DO WE WANT TO CONSIDER?

- 1  $\rightarrow$  Reserve on next cell on direction  $d_2$
- 2  $\rightarrow$  Reserve on next cells on directions  $d_2$  and  $d_1$
- 3  $\rightarrow$  Reserve on next cells on directions  $d_2, d_1$  and  $d_3$

# Mobility Analysis and Prediction

## A PRACTICAL EXAMPLE ( $n=6$ )

### HOW TO USE THE MATRIX





# Summary

- QoS in Telecommunication Systems
- Wireless Communications and Issues
- Wireless Channel Modeling
- Bandwidth Management
- Mobility Generation
- Mobility Analysis and Prediction
- Some Reachable Results and Conclusions
- Research Group Description

# Conclusions

- Needing of QoS guarantees in wireless networks;
- Influence of wireless link and how to model it;
- Importance of passive reservations;
- Impact of mobility and hand-over management;
- How to analyze and use mobility history;
- Importance of prediction in wireless networks.

# Research Group Description

## RESEARCH TOPICS

- Vehicular Ad-hoc NETworks (routing);
- Mobility models and analysis (prediction);
- Wireless Channel Modeling (stochastic proc.);
- Satellite communications (DVB-RCST);
- Wireless Sensor Networks (energy manag.);
- Delay Tolerant Networks (energy manag.);
- Underwater and Interplanetary Communications (modeling);

THANKS FOR YOUR  
ATTENTION!