Corso di QoS e Sicurezza nelle Reti
a.a. 2014-2015

Lezione del 8 Giugno 2015

Summary

-Mobility Generation

- Mobility Analysis and Prediction

Mobility Generation

Why mobility description is so important in wireless networks and research issues?

The main aim of a mobility model is the 'exact' description of users behavior during their connections with the wireless network.

For example, BS dimensioning, Congestion analysis, Predictions and other activities are not possible if mobility is not described faithfully.

Mobility Generation

How mobility can be considered [Bhandari]?

- **Trace-based** mobility models: coverage cells "trace" users movements and store data into log-files that can be used a-posteriori;
- **Synthetic** mobility models: a simulator creates users coordinates obeying to some particular laws for speed and acceleration;
- **Geographical patterns**: real roadmaps are considered (like Google maps) and users coordinates are forced to belong only to the possible paths.

[Bhandari] S. R. Bhandari, G. M. Lee and N. Crespi, "*Mobility Model for User's Realistic Behavior in Mobile Ad Hoc Network ", IEEE Communication Networks and Services Research Conference (CNSR).*

Mobility Generation

TRACE-BASED MOBILITY - EXAMPLE

an example of some syslog entries that were taken from the trace set.

986996241 Apr 11 09:37:21	AcadBldg33AP6	(Info): Station 004096daa8fe Authenticated
986996241 Apr 11 09:37:21	AcadBldg33AP6	(Info): Station 004096daa8fe Associated
986996363 Apr 11 09:39:23	AcadBldg33AP5	(Info): Station 00409630cdc9 roamed
986996363 Apr 11 09:39:23	AcadBldg33AP5	(Info): Station 00409630cdc9 roamed
986996363 Apr 11 09:39:23	AcadBldg33AP6	(Info): Station 00409630cdc9 Authenticated
986996363 Apr 11 09:39:23	AcadBldg33AP6	(Info): Station 00409630cdc9 Reassociated
986996680 Apr 11 09:44:40	AdmBldg19AP3	(Info): Station 0040961e58be Reassociated

Part of a syslog trace collected on April 11th 2001.

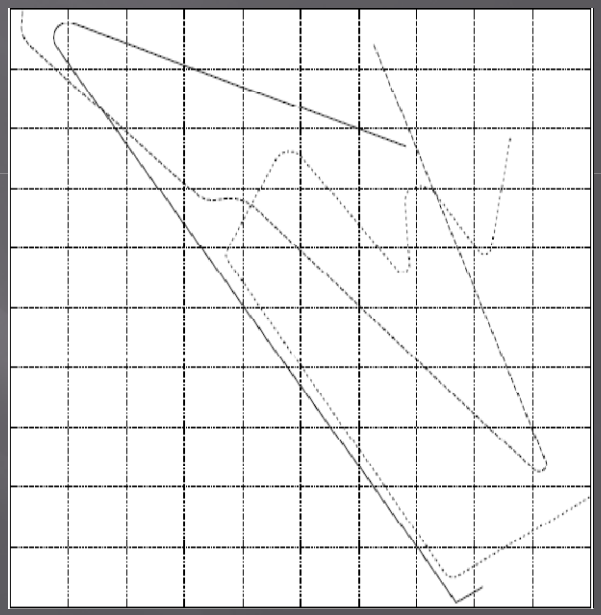
Pro: real user patterns;

Con: need of accessing TLC companies DBs.

Mobility Generation

SYNTHETIC MOBILITY – *"SOME"* EXAMPLES

- **Random WayPoint (RWP);**
- **Markovian (MK);**
- **Brownian (BR);**
- **Smooth Random (SR);**



Pro: analytical expressions available;

Con: real environments cannot be considered.

Mobility Generation
GEOGRAPHICAL PATTERNS – EXAMPLE

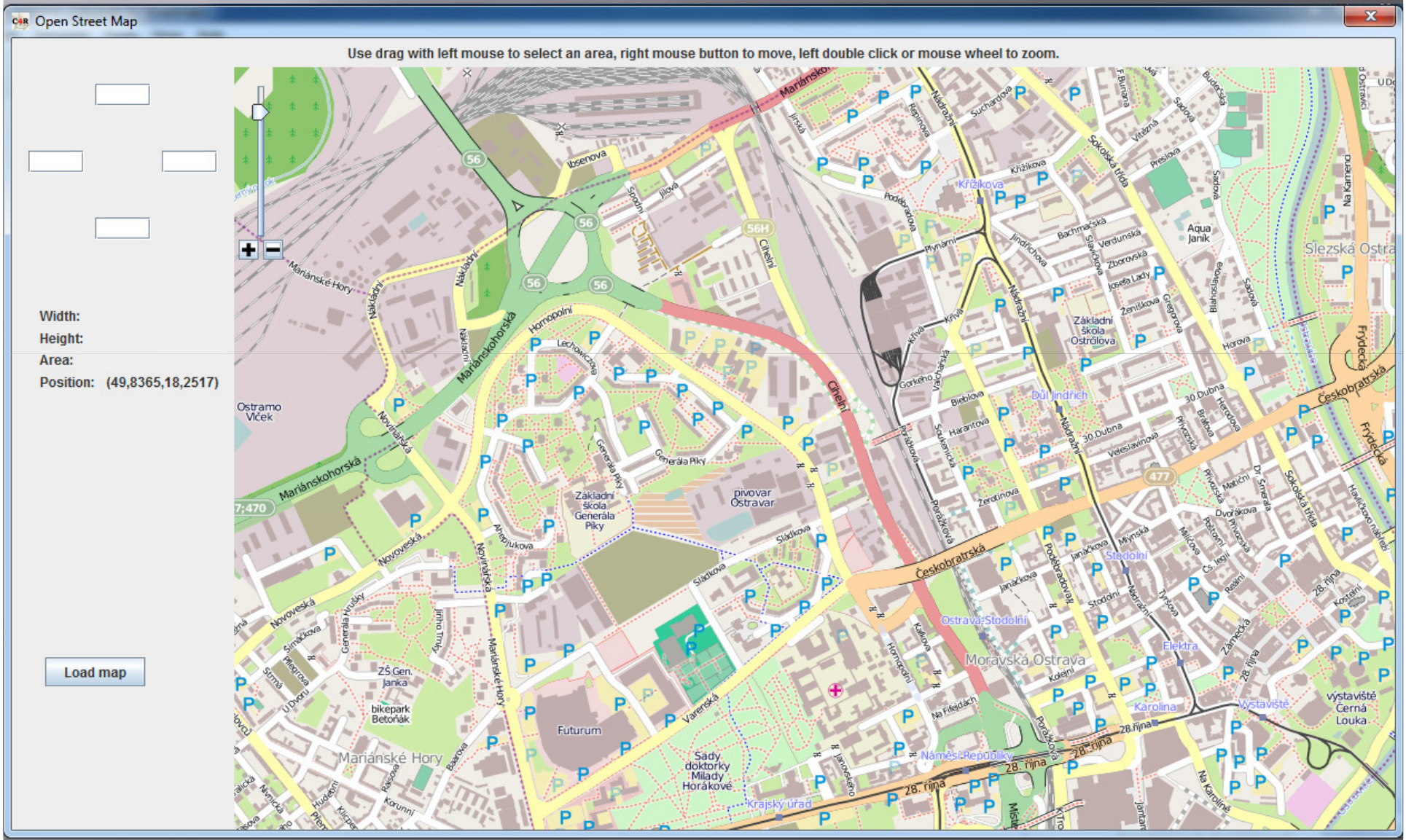
City 4 Roadmaps [Martinez]

It is a mobility generator software based on real roads (www.openstreetmap.org), which can be chosen for the considered coverage area.

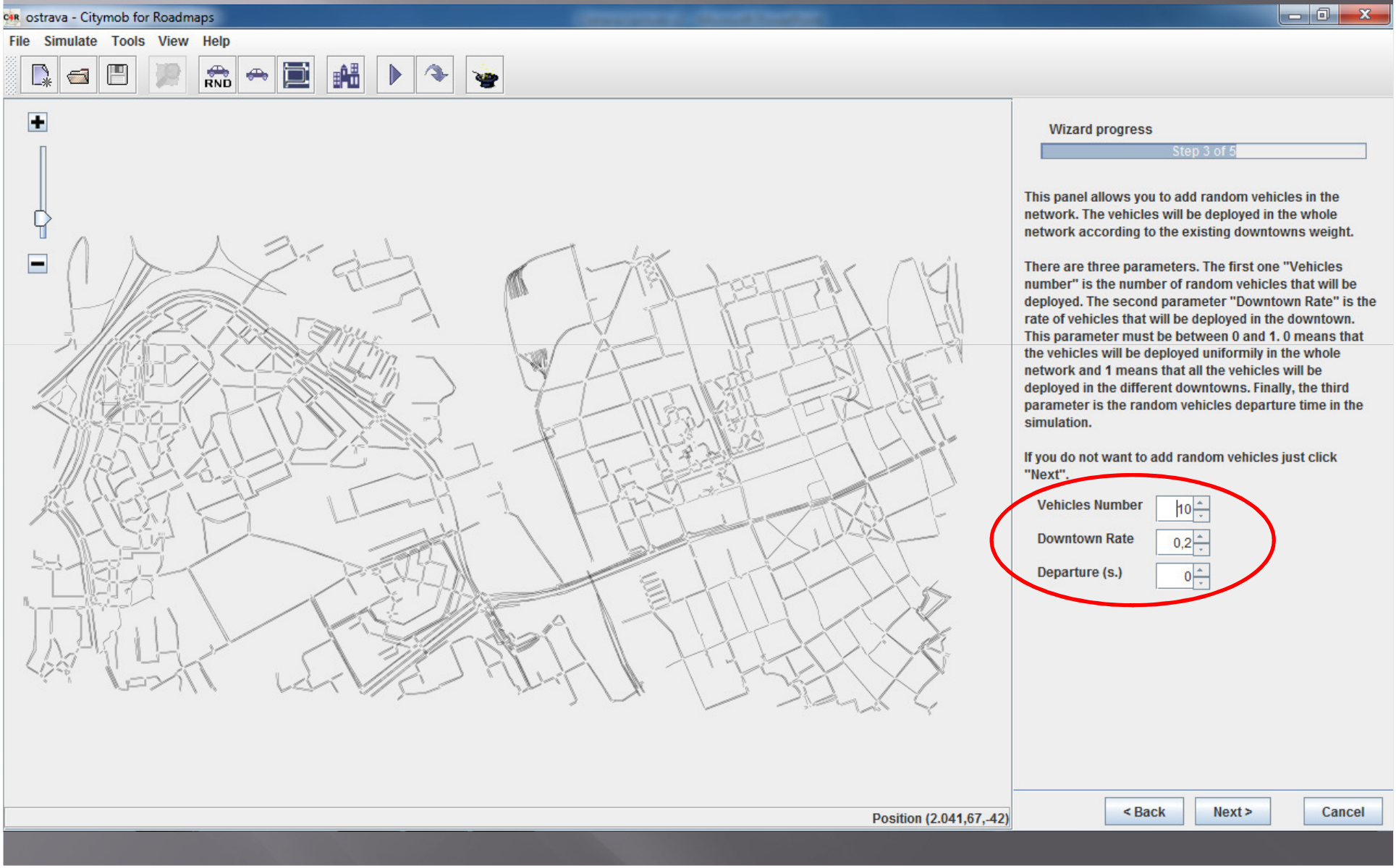
[Martinez] Martinez, F.J., Cano, J.-C., Calafate, C.T., Manzoni, P., "CityMob: A Mobility Model Pattern Generator for VANETs", IEEE ICC Workshops.

Mobility Generation

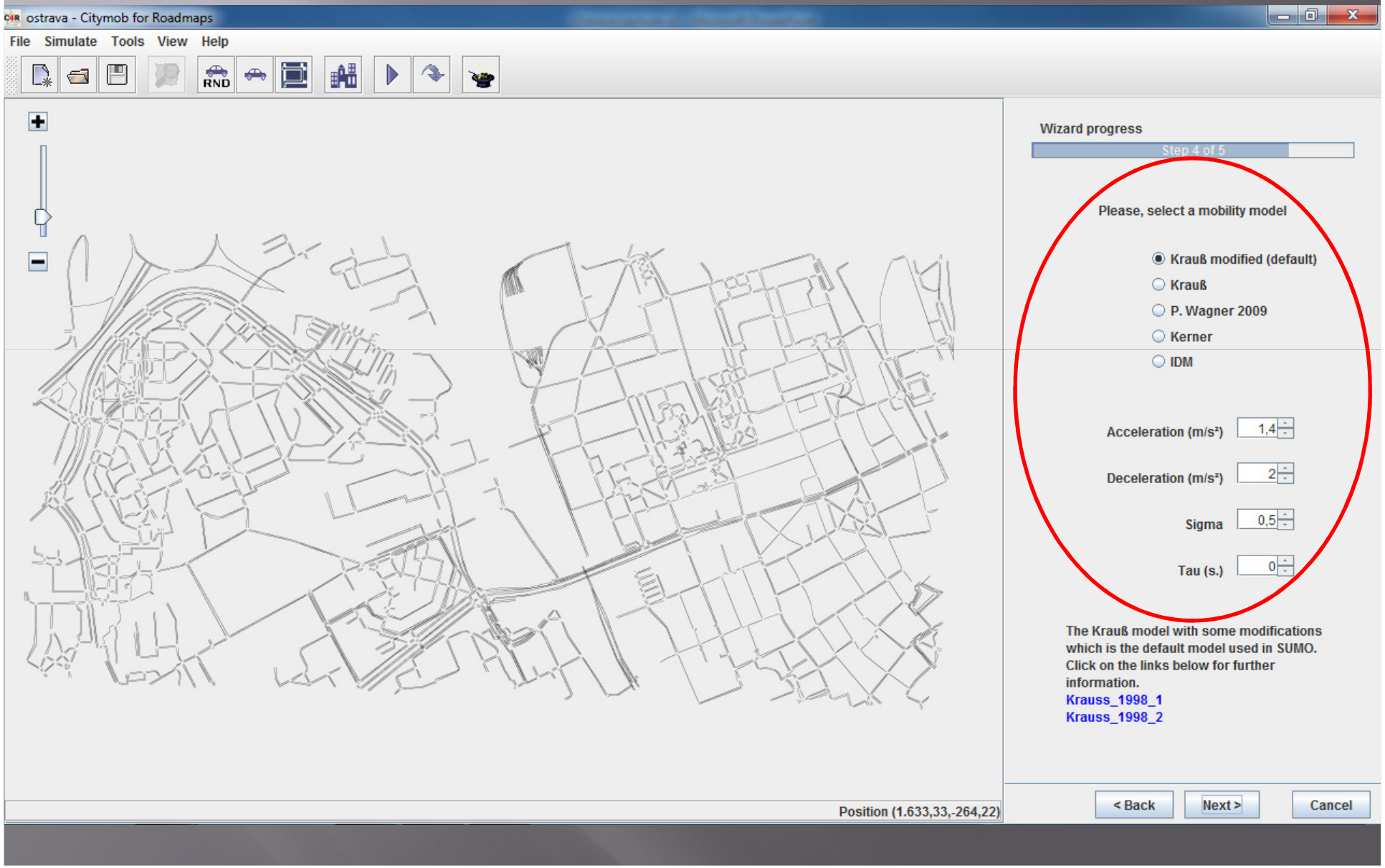
GEOGRAPHICAL PATTERNS – EXAMPLE



Mobility Generation
GEOGRAPHICAL PATTERNS – EXAMPLE



Mobility Generation
GEOGRAPHICAL PATTERNS – EXAMPLE



Mobility Generation
GEOGRAPHICAL PATTERNS – EXAMPLE

ostrava_1.tcl - Blocco note

File Modifica Formato Visualizza ?

```
# # This file was parsed with Citymob for Roadmaps (C4R) version 1.0#
#Node 0 = random_undefined_0_0$node_(0) set X_ 2094.08$node_(0) set Y_ 476.42$node_(0) set Z_ 0.0
#Node 1 = random_undefined_1_0$node_(1) set X_ 2354.33$node_(1) set Y_ 310.05$node_(1) set Z_ 0.0
#Node 2 = random_undefined_2_0$node_(2) set X_ 99.87$node_(2) set Y_ 587.89$node_(2) set Z_ 0.0
#Node 3 = random_undefined_3_0$node_(3) set X_ 2363.95$node_(3) set Y_ 307.37$node_(3) set Z_ 0.0
#Node 4 = random_undefined_4_0$node_(4) set X_ 2345.17$node_(4) set Y_ 949.64$node_(4) set Z_ 0.0
#Node 5 = random_undefined_5_0$node_(5) set X_ 282.65$node_(5) set Y_ 817.64$node_(5) set Z_ 0.0
#Node 6 = random_undefined_6_0$node_(6) set X_ 1758.46$node_(6) set Y_ 577.04$node_(6) set Z_ 0.0
#Node 7 = random_undefined_7_0$node_(7) set X_ 2183.79$node_(7) set Y_ 502.41$node_(7) set Z_ 0.0
#Node 8 = random_undefined_8_0$node_(8) set X_ 269.04$node_(8) set Y_ 803.35$node_(8) set Z_ 0.0
#Node 9 = random_undefined_9_0$node_(9) set X_ 118.54$node_(9) set Y_ 128.36$node_(9) set Z_ 0.0
#Path $node_(0) = random_undefined_0_0$ns_ at 0.0 "$node_(0) setdest 2093.740012487098 477.4556198583798 1.0899999999999674"$ns_ at 1.0 "$node_(0) setdest 20
t 2073.5232046030173 545.5244995463597 15.01581858386642"$ns_ at 12.0 "$node_(0) setdest 2066.7166037104716 549.5737691458795 7.919999999999944"$ns_ at 13.0
ns_ at 23.0 "$node_(0) setdest 1979.7939197180392 541.0197552749157 6.990000000000066"$ns_ at 24.0 "$node_(0) setdest 1972.0109689989022 538.6697386572117 8.
.71697822571014 17.22038139989768"$ns_ at 35.0 "$node_(0) setdest 1840.9346256293325 499.27201249728455 8.219884391967515"$ns_ at 36.0 "$node_(0) setdest 183
"$node_(0) setdest 1711.9689382602492 462.8689889286944 9.519999999999843"$ns_ at 47.0 "$node_(0) setdest 1704.8219968849603 460.4978860253633 7.530000000000
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setdest 1462.0612339239644 369.06211928455133 14.246403258255244"$ns_ at 70.0 "$node_(0) setdest 1449.4070148702365 363.9441860942618 13.649999999999996"$ns_
500000000000135"$ns_ at 81.0 "$node_(0) setdest 1307.7203504884594 318.66266622232337 13.809999999999915"$ns_ at 82.0 "$node_(0) setdest 1294.5179664531222 31
dest 1142.7416929833369 278.52782213957624 24.039769935939255"$ns_ at 93.0 "$node_(0) setdest 1131.6495335068382 270.58971164979823 13.640000000000008"$ns_ at
42 13.450000000000005"$ns_ at 104.0 "$node_(0) setdest 1005.9500428208664 172.80086083311129 23.200025551125457"$ns_ at 105.0 "$node_(0) setdest 995.395609677
st 888.7688165944278 80.23735063785132 13.719999999999972"$ns_ at 116.0 "$node_(0) setdest 878.0410013192026 71.7648728762608 13.670000000000006"$ns_ at 117.0
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#Path $node_(1) = random_undefined_1_0$ns_ at 0.0 "$node_(1) setdest 2353.0054525598275 309.5965972224026 1.4000000000001247"$ns_ at 1.0 "$node_(1) setdest 2
2307.9286648654397 247.5259645679489 8.150000000000023"$ns_ at 12.0 "$node_(1) setdest 2313.369721460062 241.53906193519177 8.089999999999982"$ns_ at 13.0 "$n
"$ns_ at 23.0 "$node_(1) setdest 2295.4450095081106 186.5508916712744 5.637324224248126"$ns_ at 24.0 "$node_(1) setdest 2288.9046480278694 181.857686827271 8
2.87296013672962 7.91000000000004"$ns_ at 35.0 "$node_(1) setdest 2228.227020533842 106.764022020548 7.830000000000047"$ns_ at 36.0 "$node_(1) setdest 2219.4
tdest 2161.8452930468975 61.615805377131025 10.139999999999862"$ns_ at 47.0 "$node_(1) setdest 2154.5670406815557 69.99655966934111 11.100000000000067"$ns_ a
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08145407439 5.3899999999999935"$ns_ at 116.0 "$node_(1) setdest 1666.8038015018853 446.5005573228312 6.410000000000112"$ns_ at 117.0 "$node_(1) setdest 1659.
at 127.0 "$node_(1) setdest 1534.5081353755427 398.31481731893456 13.744318177408003"$ns_ at 128.0 "$node_(1) setdest 1522.0227642093216 393.313248863154 13.4
00158056533 342.2535175699035 13.879864140678968"$ns_ at 139.0 "$node_(1) setdest 1382.7762270017322 337.3317361840561 13.539999999999994"$ns_ at 140.0 "$nod
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de_(1) setdest 1123.4930555340172 264.7525233644262 9.749999999999991"$ns_ at 162.0 "$node_(1) setdest 1115.0275584555457 258.6941853733273 10.410000000000165
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1) setdest 874.9882433513441 69.35390444227492 13.52"$ns_ at 185.0 "$node_(1) setdest 862.5410981843245 64.56258554430119 13.337472009003028"$ns_ at 186.0 "$
999999974"$ns_ at 196.0 "$node_(1) setdest 782.5925095988308 212.64731110455918 22.93644652828363"$ns_ at 197.0 "$node_(1) setdest 771.7147506799487 233.0778
698.012799745916 289.59744410212386 8.310000000000077"$ns_ at 208.0 "$node_(1) setdest 691.1883235592163 285.86181500153486 7.779999999999922"$ns_ at 209.0 "
$ns_ at 219.0 "$node_(1) setdest 613.4787675978107 243.32461936899256 8.169999999999982"$ns_ at 220.0 "$node_(1) setdest 606.2858749588726 239.3873239159296
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est 120.68106425107 42 512.7358679654897 8.090022332257925"$ns_ at 12.0 "$node_(2) setdest 125.03026701302244 506.297130873834 7.770000000000017"$ns_ at 13.0
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_(2) setdest 494.7396752435153 240.52508104486586 7.999999999999984"$ns_ at 84.0 "$node_(2) setdest 498.4584073892669 233.72555670649083 7.750000000000025"$n
9999999999922"$ns_ at 95.0 "$node_(2) setdest 568.0835673838606 214.7075428683305 8.290000000000006"$ns_ at 96.0 "$node_(2) setdest 575.3815673977701 218.7027
```

sabato 3 novembre 2012

Mobility Generation

Once the patterns coordinates have been created, they can be used for the desired purposes. In our fields of research, mobility patterns have to be **analyzed** accurately.

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

Mobility Analysis and Prediction

Let us recall what previously exposed:

Bandwidth Management

Passive Reservation Issues

1) First of all, the time spent in each cell has to be considered (Cell Stay Time – CST);

2) The number of hand-over events has to be evaluated, so the coverage network can know how many cells a mobile host will visit;

3) For 2D scenarios, the exact cells that a mobile host will visit need to be identified.

Let us see how mobility can be "generated" and, then, analyzed.

How can the CST be evaluated?

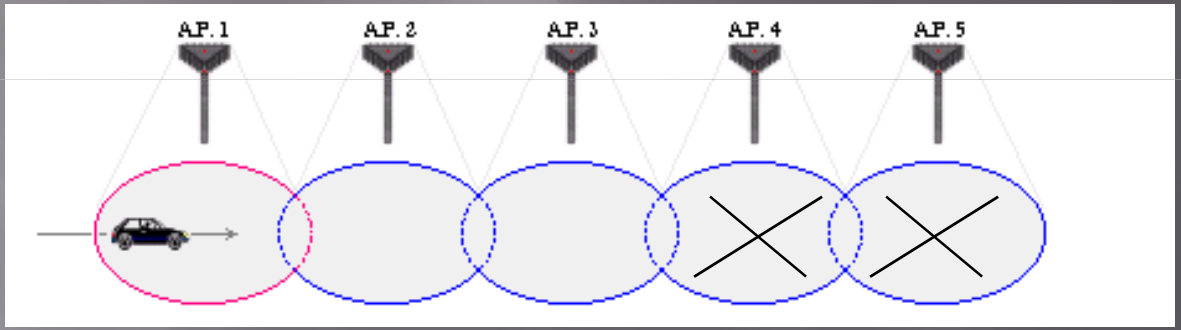
How can the number of h.o. be evaluated?

What cells will a mobile host visit?

Mobility Analysis and Prediction

How to evaluate the CST

Mono-dimensional case: depending on its mobility characteristics, a single user may not visit all the cells of the system:

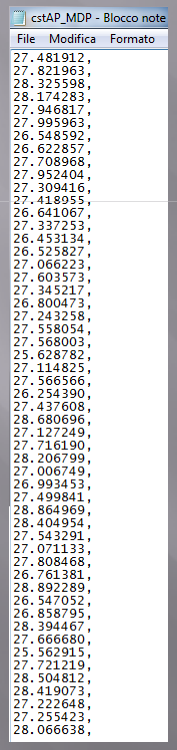


CST can be evaluated by observing users mobility through simulations campaigns, considering the time spent by a single user under a cell coverage area.

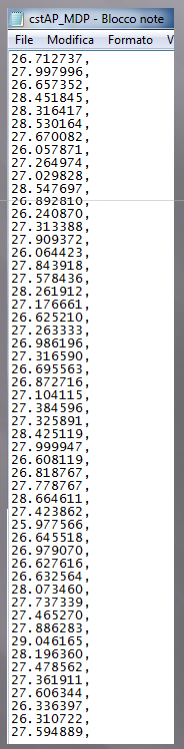
Mobility Analysis and Prediction

How to evaluate the CST – simulation campaigns

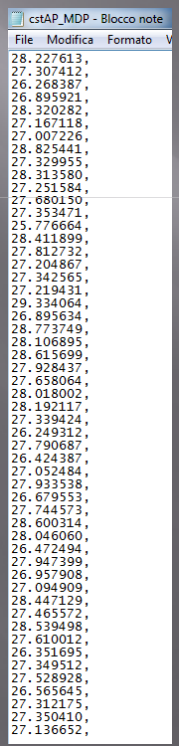
Mono-dimensional case: for each cell of the system the hand-in arrival and hand-out departure times are stored.



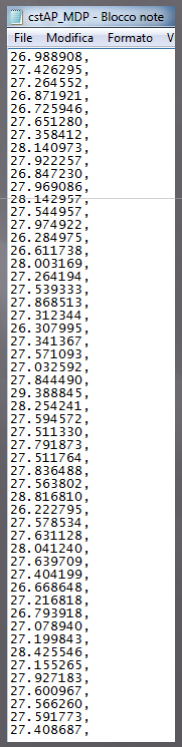
Cell 1



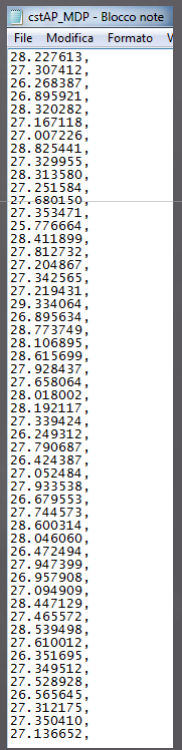
Cell 2



Cell 3



Cell 4

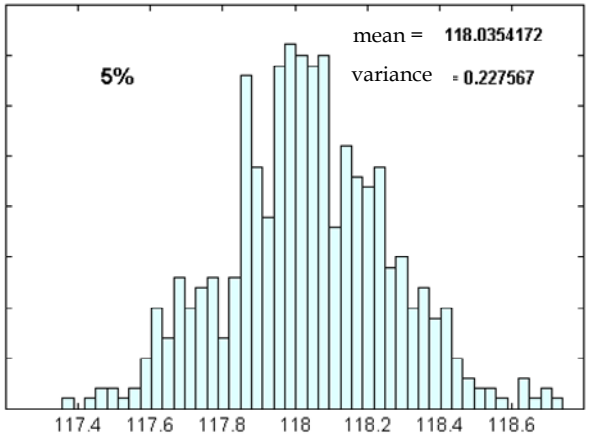


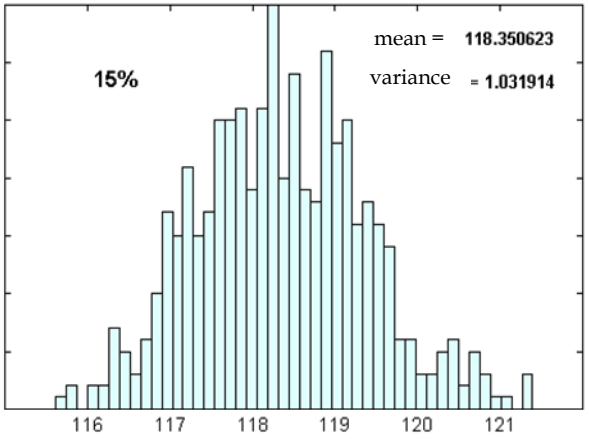
Cell 5

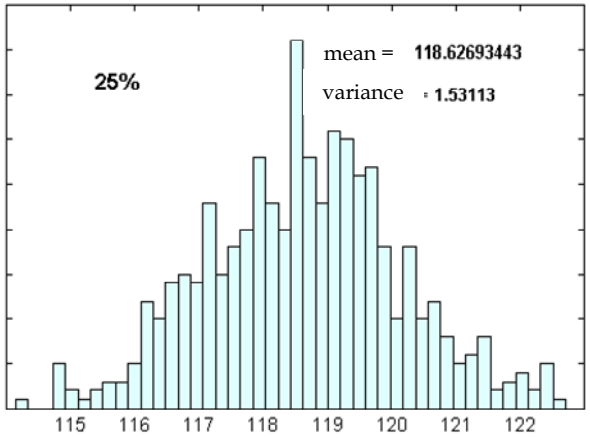
Mobility Analysis and Prediction

How to evaluate the CST – simulation campaigns

Mono-dimensional case: for each run of simulation campaigns the obtained results are averaged.







GAUSSIAN DISTRIBUTIONS CAN BE CONSIDERED!

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:

$$C_p = \left\lceil \frac{T_{CHT}}{T_{CST}} \right\rceil$$

$$f(x) = \frac{1}{\mu} e^{-\frac{x}{\mu}}$$

Exponential distribution
(from literature)

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

Gaussian distribution

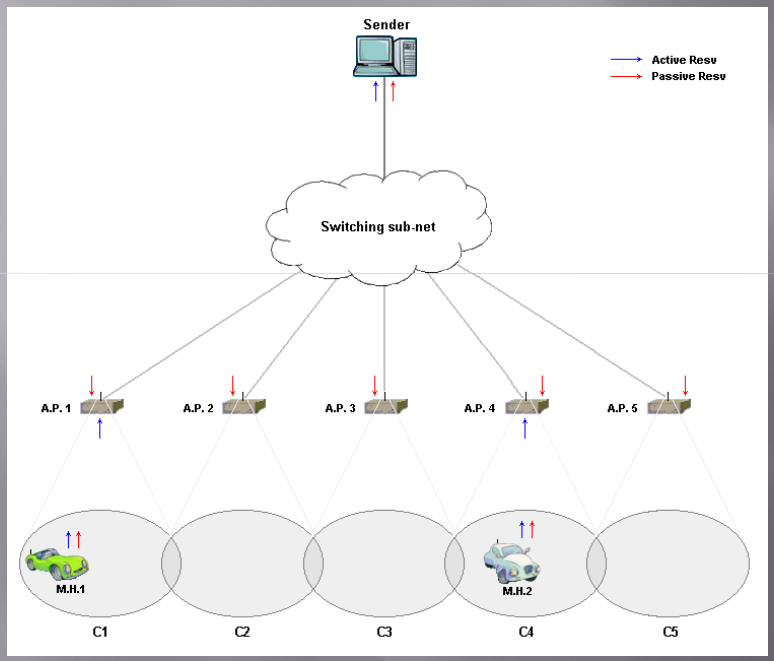
The value of Cp is used only for a quantitive purpose and the assumption of a CST normally distributed has been verified through a KS-test.

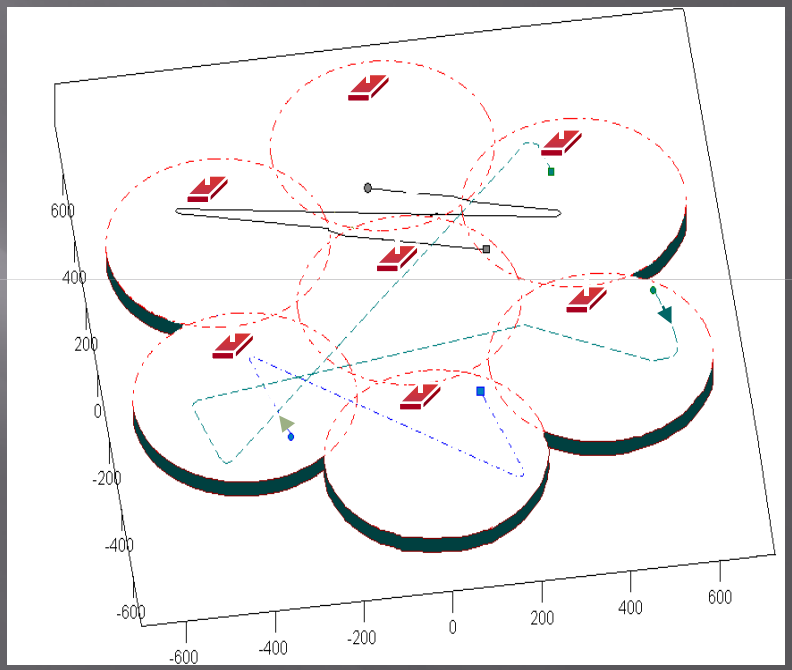
WHAT ABOUT 2D ENVIRONMENT?

Mobility Analysis and Prediction

From 1D to 2D

Let us now consider real scenarios (2D):



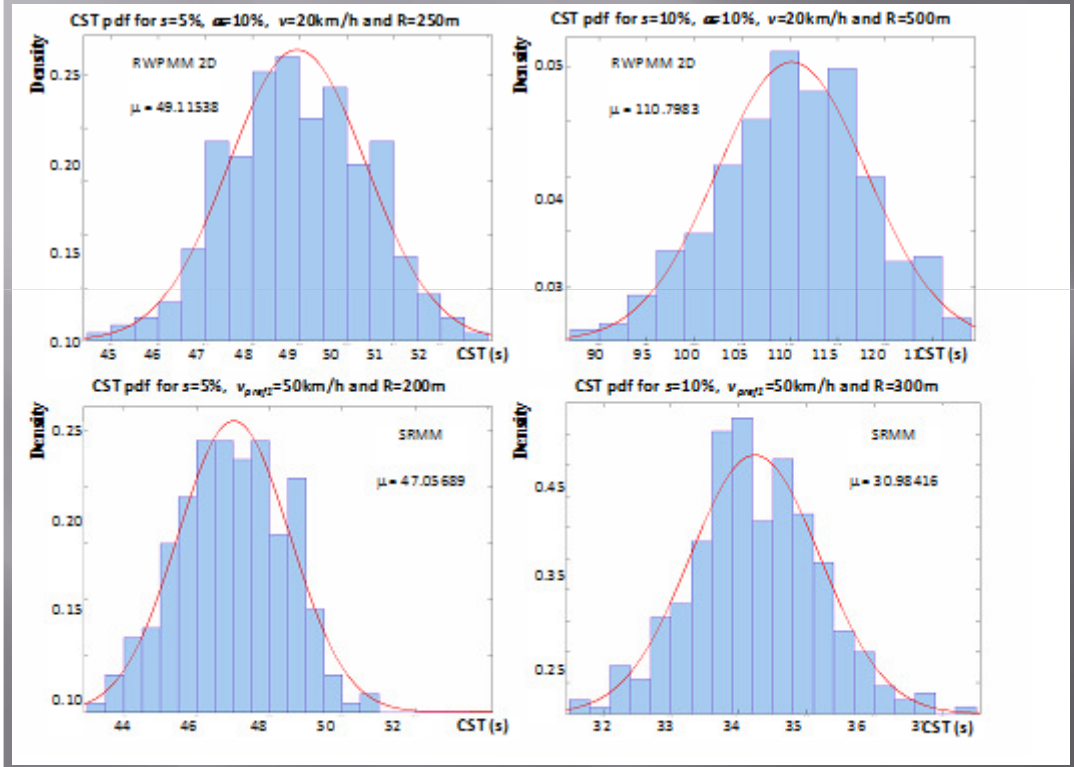


Are there new issues?

Mobility Analysis and Prediction

From 1D to 2D

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

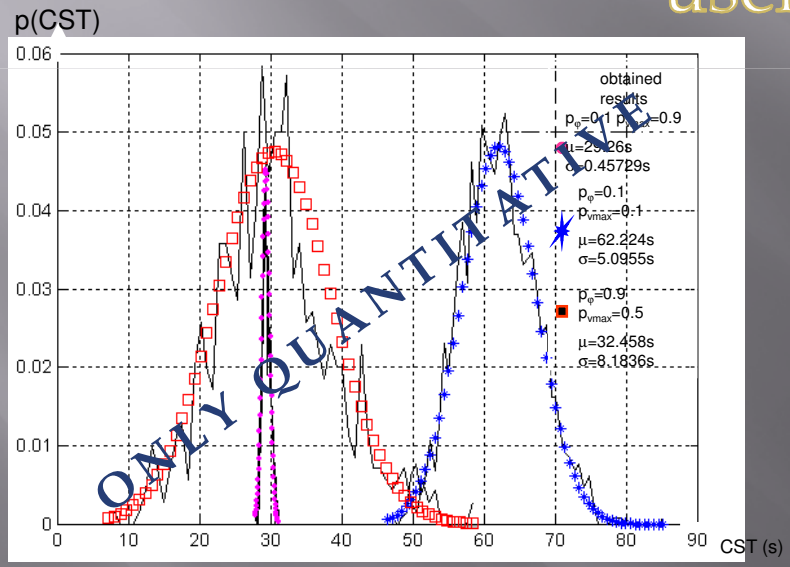


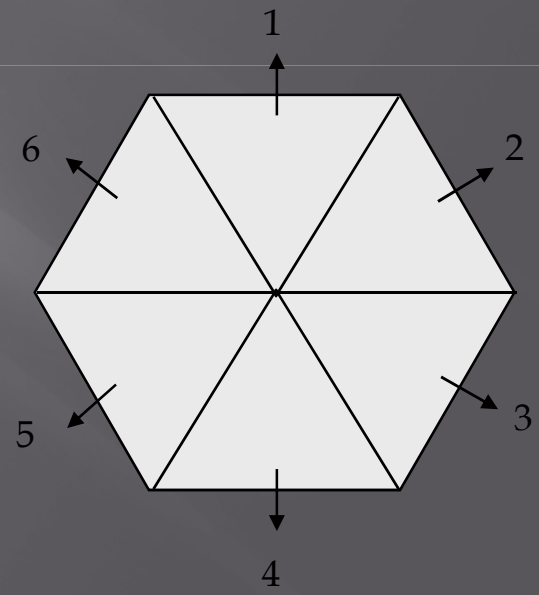
The same considerations of the previous case (1D) can be made for 2D models (like RWP and SR). The hypothesis of Gaussian distribution is still valid.

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.



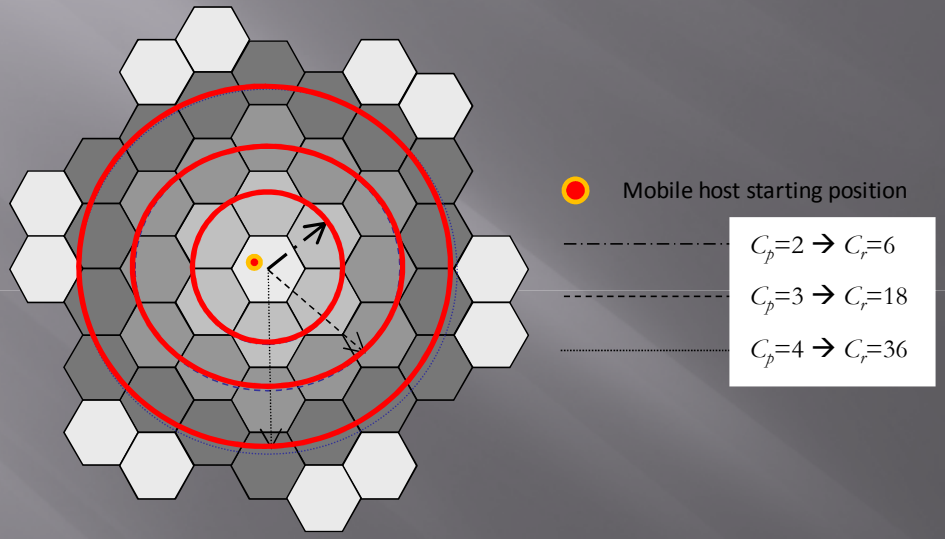


The possibly preferred movement directions of users must be taken into account, so a **qualitative** analysis becomes feasible.

Mobility Analysis and Prediction

From 1D to 2D

WHY QUALITATIVE ANALYSIS IS NEEDED IN 2D?



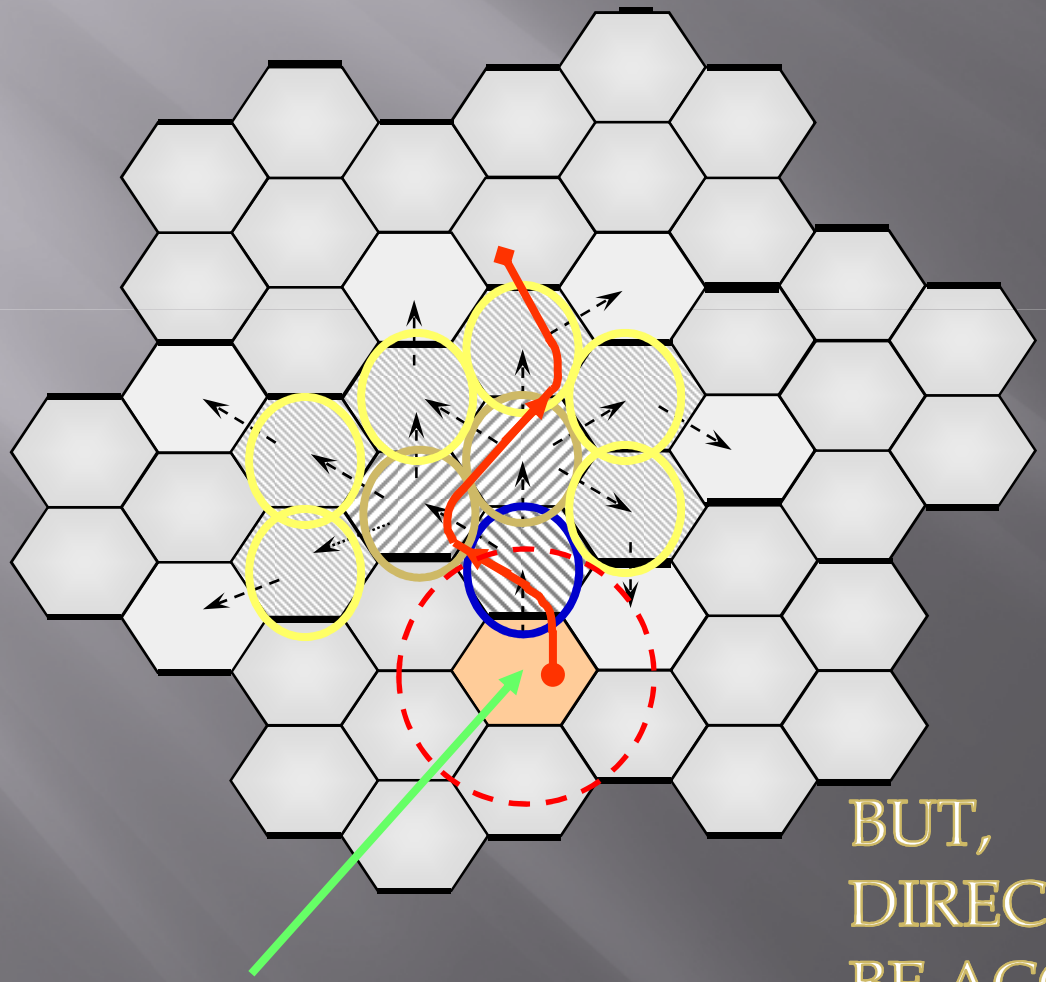
$$C_r = 3 \cdot C_p \cdot (C_p - 1)$$

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 Cp=5 we have Cr=60!!!).

Mobility Analysis and Prediction

From 1D to 2D

WHY QUALITATIVE ANALYSIS IS NEEDED IN 2D?



The number of passive reservations is drastically reduced because the circular reservation is not needed now, since directional information is available.

BUT, HOW CAN DIRECTIONAL BEHAVIOR BE ACCOUNTED FOR?

Mobility Analysis and Prediction

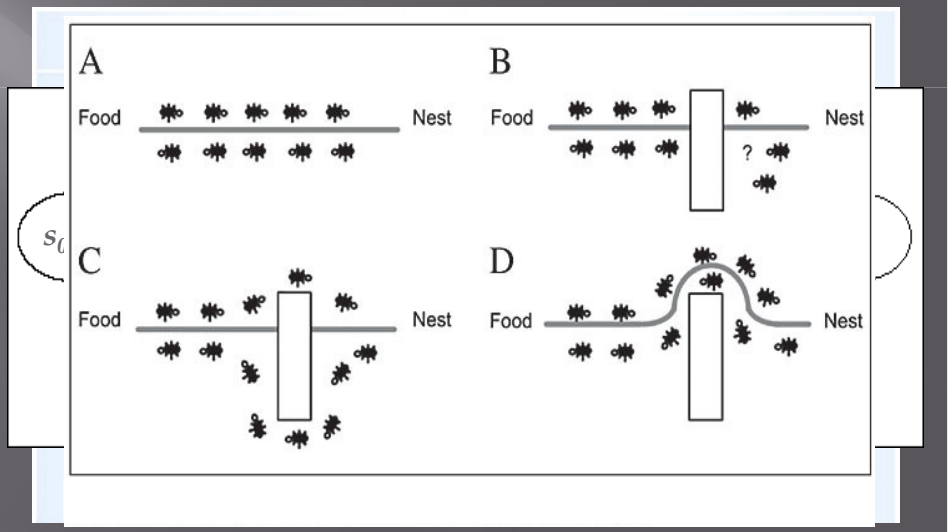
DIRECTIONAL ANALYSIS IN 2D SCENARIOS

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

NEURAL NETWORKS

MARKOV CHAINS

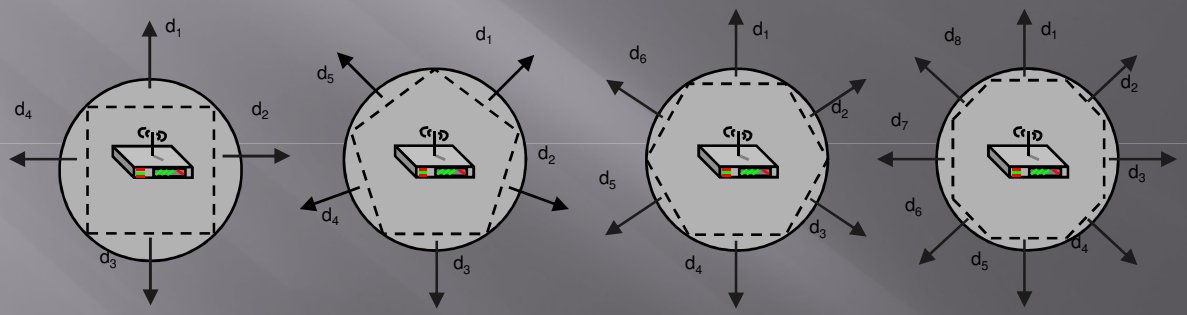
SWARM INTELLIGENCE



ANALYTICAL AND STATISTICAL TOOLS

Mobility Analysis and Prediction
A PRACTICAL EXAMPLE

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



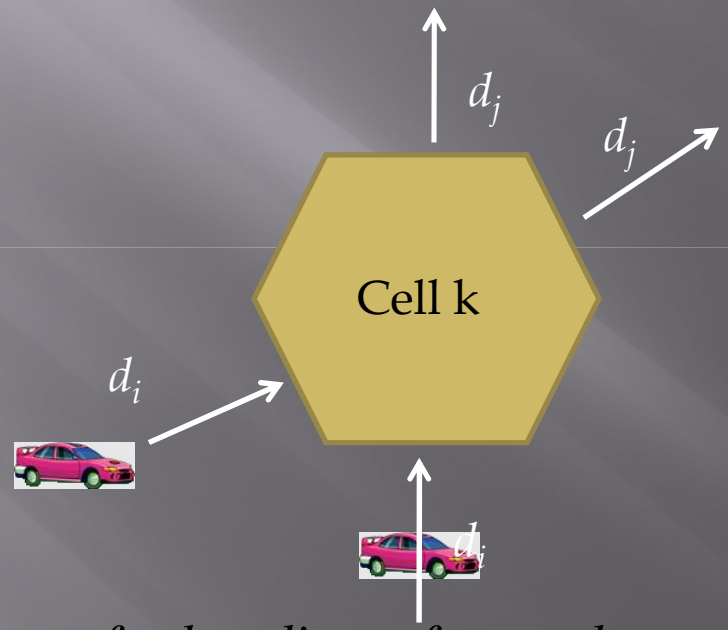
Then a *nxn* matrix can be considered, where the rows indicate the hand-in directions and the columns the hand-out directions; the elements are defined as:

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

Mobility Analysis and Prediction

A PRACTICAL EXAMPLE (n=6)

How the elements of the matrix M can be obtained?



$$M_k(i,j) = \frac{Number\_of\_handins\_from\_d_i\_and\_handout\_to\_d_j}{Number\_of\_total\_handins\_from\_d_i}$$

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
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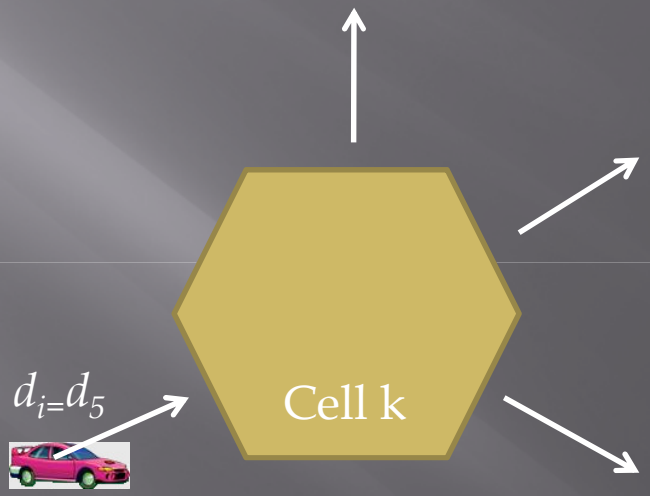

HOW MANY NEIGHBORS DO WE WANT TO CONSIDER?

1 → Reserve on next cell on direction d_2

2 → Reserve on next cells on directions d_2 and d_1

3 → 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