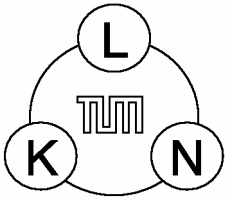

Mobility Modelling: Sense or Nonsense? - ITG Fachgruppentagung München, 24.03.06

Hans-Martin Zimmermann

zimmermann@tum.de

Munich University of Technology

Institute of Communication Networks

Prof. Dr.-Ing. J. Eberspächer

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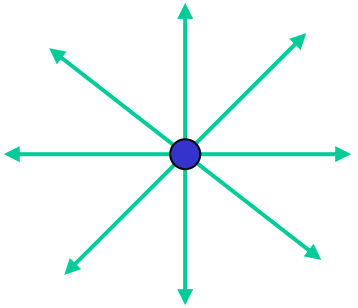
Illustrating Example “Ruck-Zuck”

“In the simulated environment, there are 50 nodes moving within a 1000m by 1000m area. Initial locations of these nodes are randomly initialized. Each node selects one of eight possible directions and moves at a speed of 10 meters per second for a second, and pauses at the intermediate position for one second. The process is continued for ten second during the simulation.”

- taken from a review (1/2006)



duration:	**10s**
pause time:	**5 x 1s**
speed:	**10 m/s**

Sense or Nonsense?

typical slogans:

- **„there are already 1000 mobility models out there“**
- **„just take random waypoint“**
- **„at least something‘s moving“**

typical domains:

- **ad hoc**
- **plain field cellular**
- **highway**
- **urban**
- **indoor**

Why still care about mobility modelling?

Mobility Modeling – a solved research issue?

principle problems:
general statement vs. detailed scenario
new effects vs. old models
modelling vs. reality

Mobility Modelling – The Challenge

modelling **vs.** **reality**

... by synthetic models

+ flexible

- no realistic movement (e.g. Random Waypoint)

- no realistic scenarios (e.g. Free Space)

... by traces

+ real

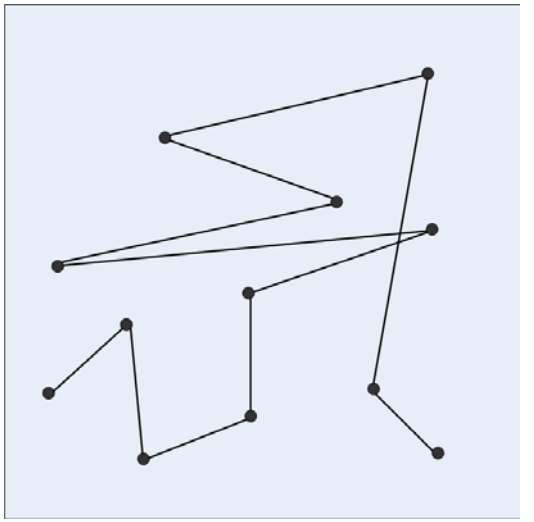
- expensive

- unflexible

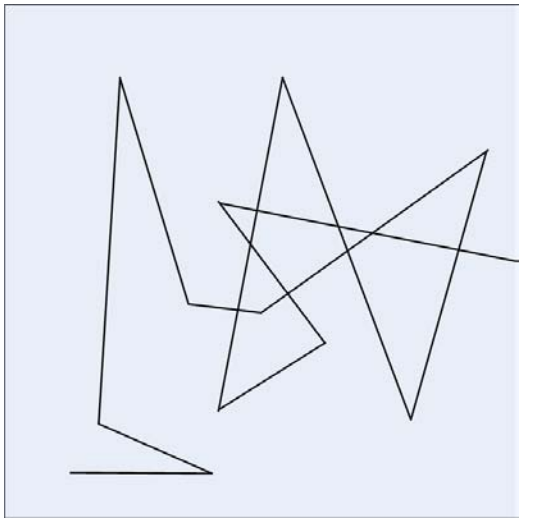
The challenge:
models as a mirror of reality –
adequate, but still easy to handle

Random Waypoint / Random Direction

- **Random Waypoint Mobility Model**
  - choose random speed
  - choose random destination point
  - include pause time
  - problem: steady-state

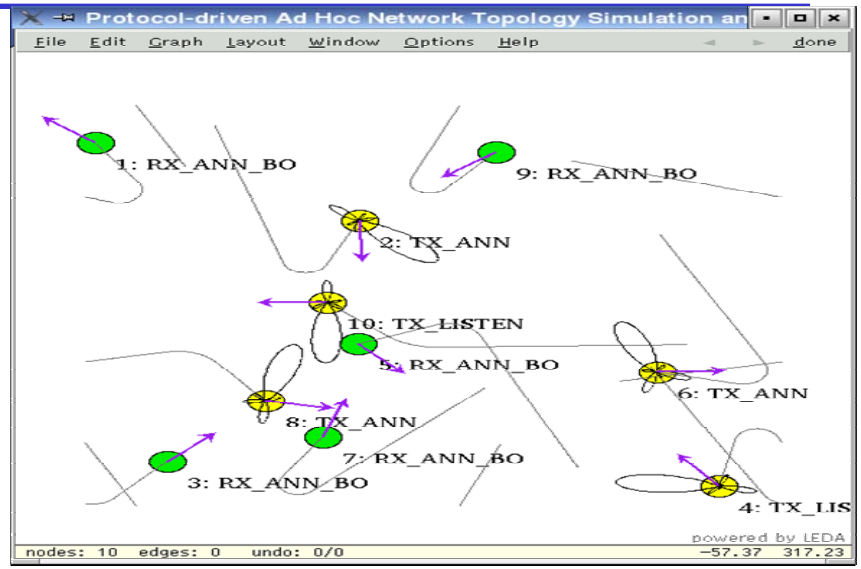


- **Random Direction Mobility Model**
  - choose random direction
  - choose random speed
  - choose update time interval

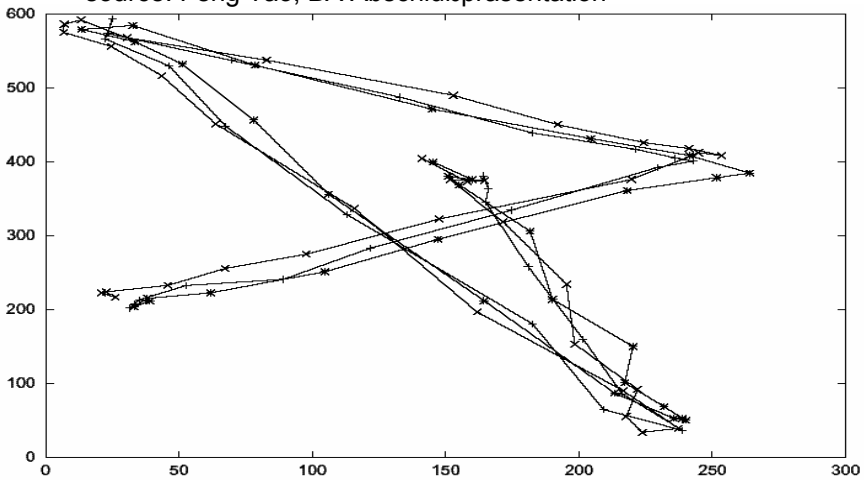


Smooth Random Direction / Group Mobility

- **Smooth Random Direction Mobility Model**
  - keep random direction model
  - smooth turnarounds
- **Group Mobility Model**
  - define moving centre / motion vector for group mobility
  - define individual motion of the group members in correlation to the central reference



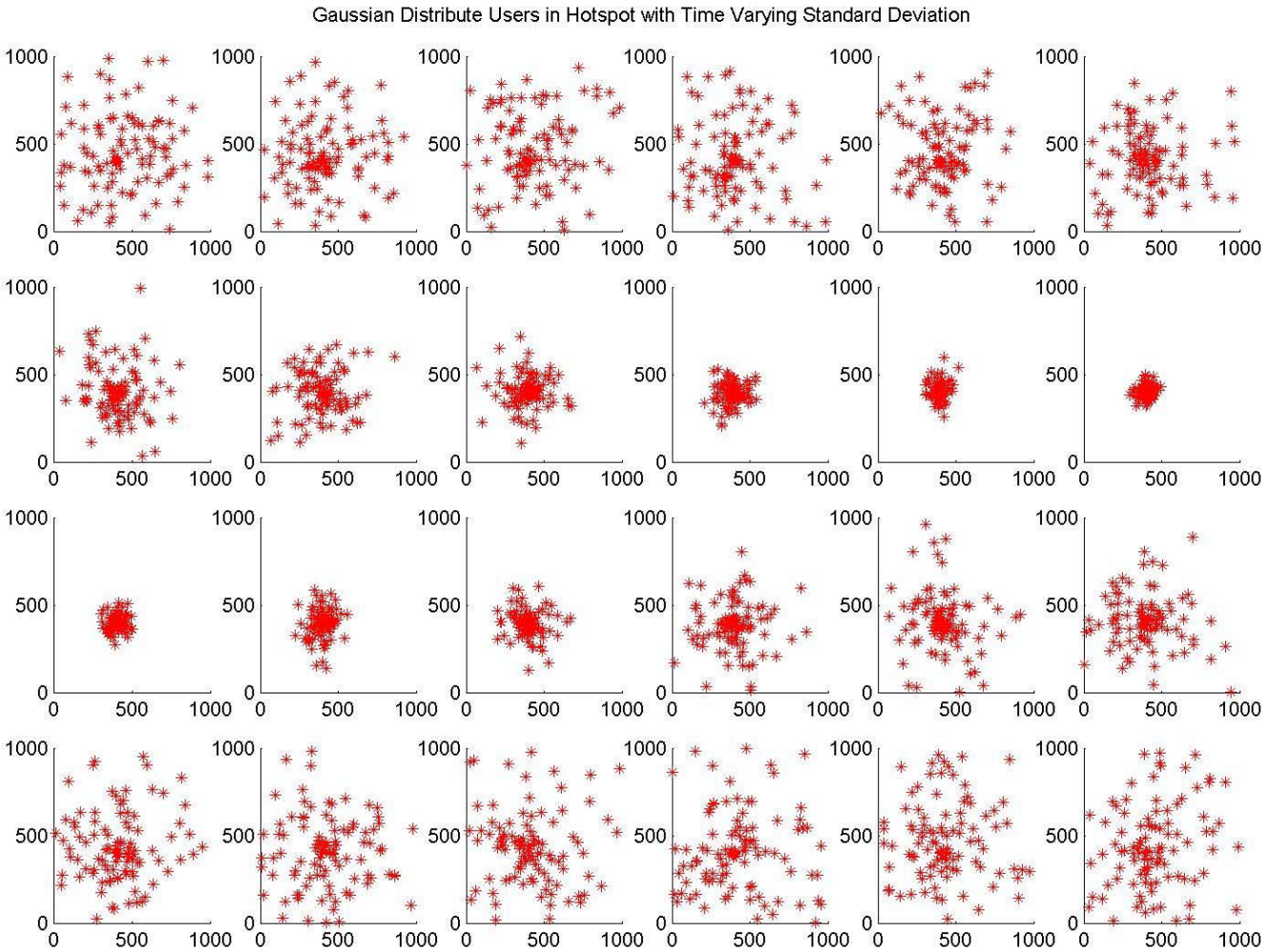
source: Feng Tao, BA Abschlußpräsentation



source: “A survey of Mobility Models for Ad Hoc Network Research”

Moving HotSpot Mobility

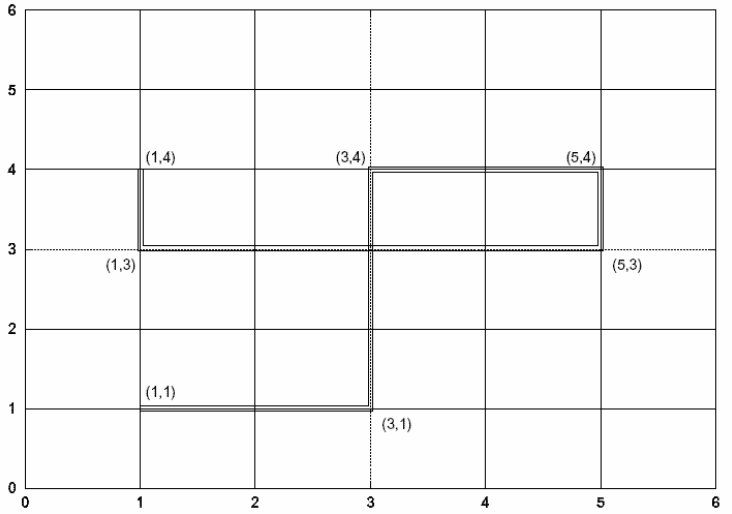
- **Gauss-distribution with time varying standard deviation**
- **24 snap-shots to model a day perspective**



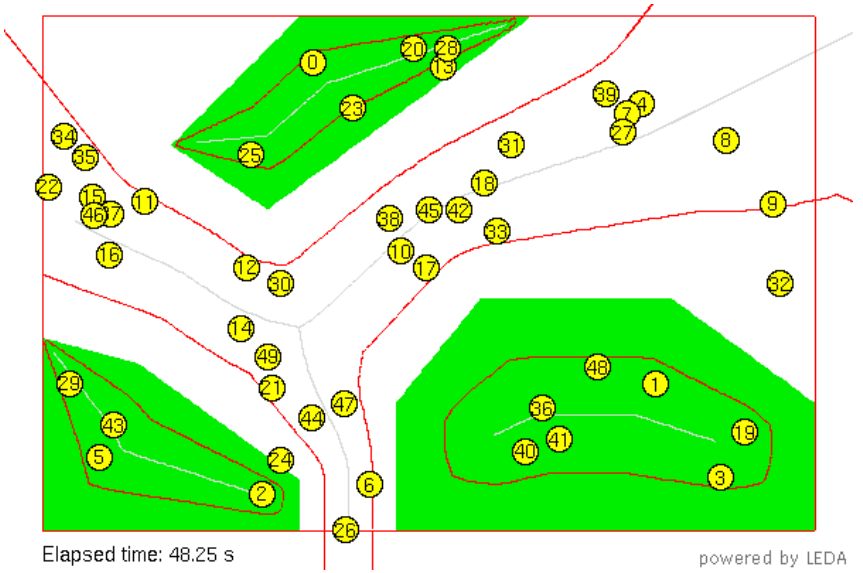
source: R. Abou-Jaoude, Ph.D. Progress Presentation

City Section Mobility / Voronoi Mobility

- **City Section Mobility Model**
  - define of set of paths/ roads
  - choose/ update velocity
  - define probability for turn-around at cross-ways



- **Voronoi Mobility Model**
  - twofold application of Voronoi graph theory
  - combined with city motion mobility model



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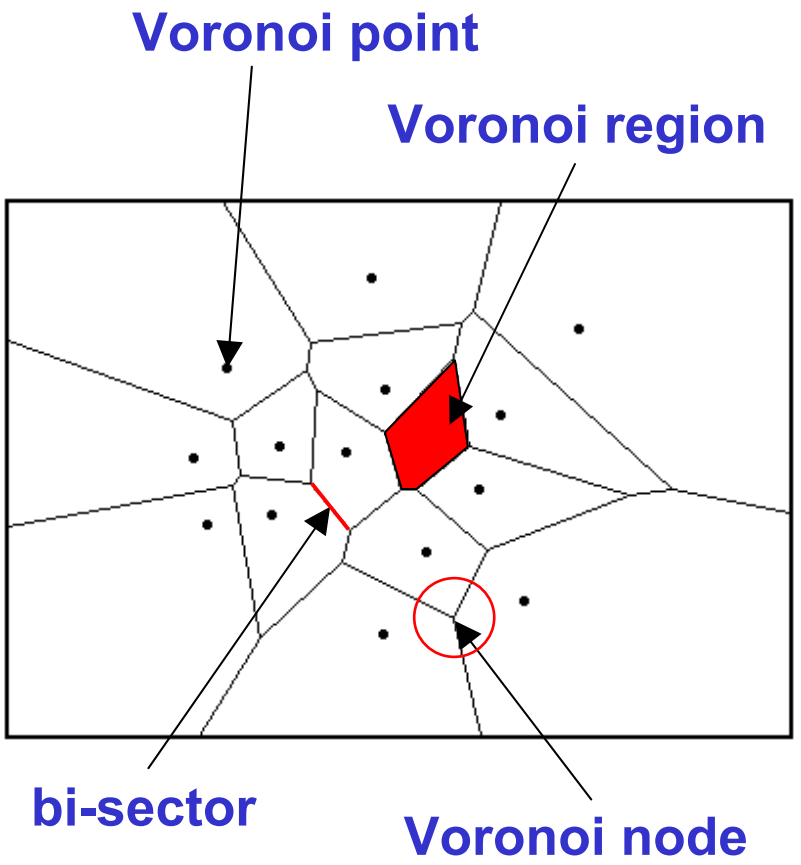
- **Part III Voronoi Mobility Model**
  - **Model & Functionality**
  - **yet another Mobility Model?**

Voronoi Graphs

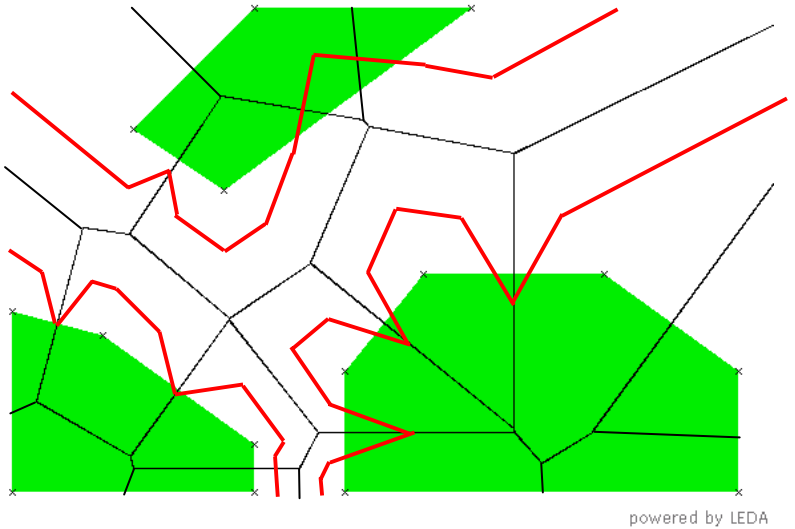
- Define V to be a set of Voronoi points v in a plane P:
  VcP and v∈V.
- The Voronoi region of v is defined as the subset of points p ∈ P that lie nearest to v.
- "Nearest" is defined by a given metric, e.g. Euclidean.
- Bi-sectors separate Voronoi regions.
- A Voronoi node is crossing point of several bi-sectors.



source: http://www.kopfmensch.privat.t-online.de

Voronoi-based Obstacle Model

- **Obstacle Mobility Model[1]**
  - **building corner as Voronoi points**
  - **Voronoi graph as predefined movement path between buildings**
- **Voronoi Obstacle Model**
  - **Voronoi nodes of the first graph used as Voronoi points for the second calculation**

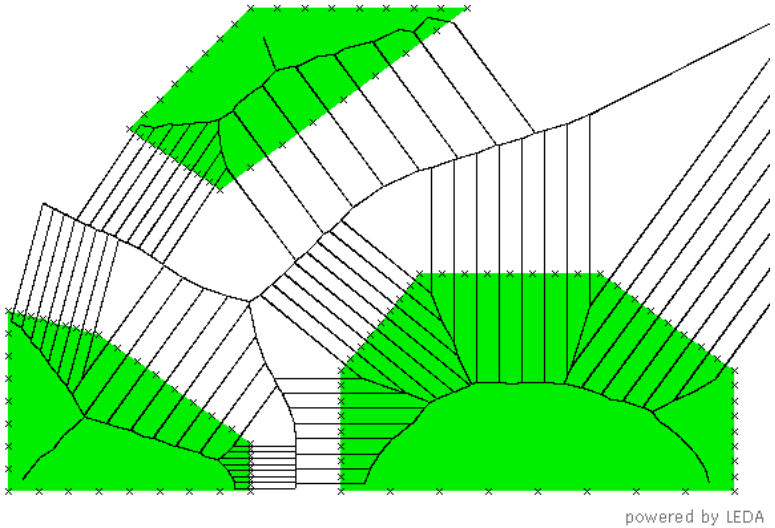


Voronoi graph of first order
...and second order

[1] Jardosh et al, Towards Realistic Mobility Models For Mobile Ad Hoc Networks, *Proceedings of MobiCom*, San Diego, CA, September 2003

Interpolation to Smooth Graph

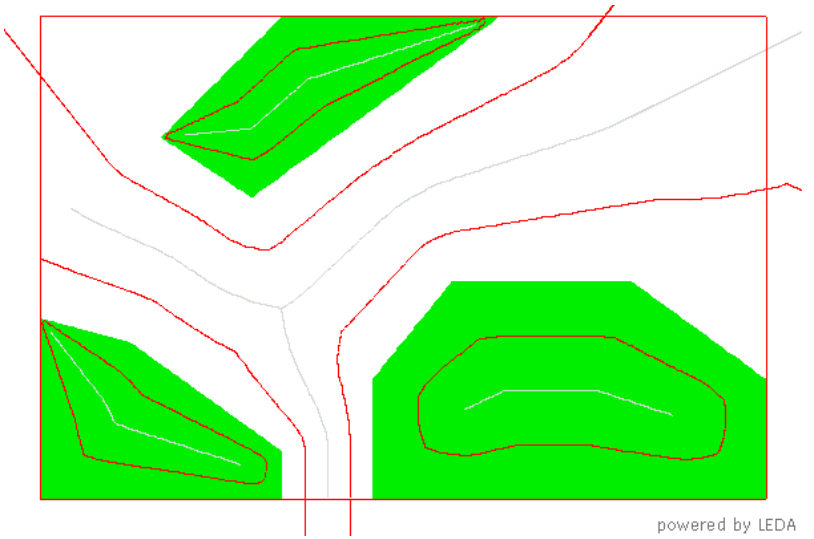
- linear interpolation of the edges:
  - interpolation factor i
  - 2^i-1 interpolation points
  - higher resolution of the building representation
- effects on Voronoi Graph:
  - increases number of Voronoi bi-sectors
  - smoothes initial Voronoi graph



interpolated Voronoi graph of first ord

Calculating the Movement Channel

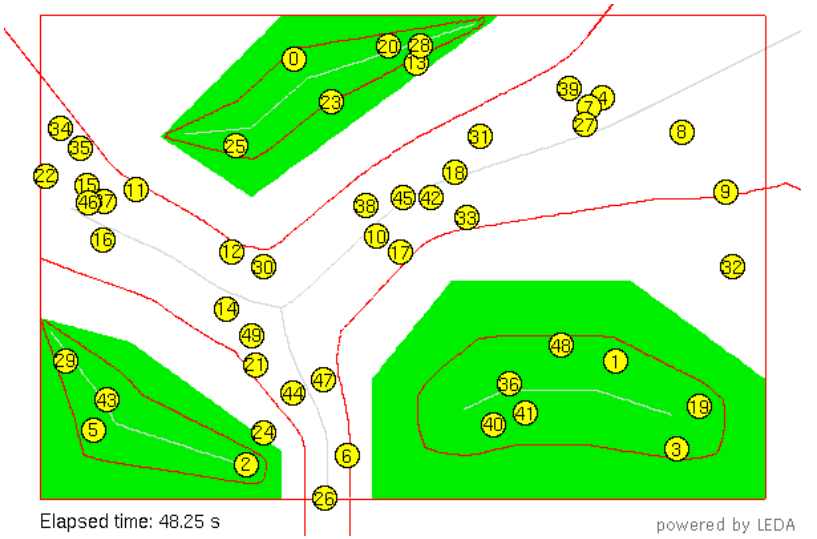
- **merge building nodes and first Voronoi graph's nodes**
- **calculate second Voronoi graph**
- **remove useless edges as**
  - **cutting edges,**
  - **graph branches, and**
  - **edges within movement channel**
- **results in movement channels**



Voronoi graph of second order

Voronoi Mobility Model

- **characteristics**:
  - **about equal node distribution within the movement channels**
  - **bouncing ball behavior**
  - **transitions to buildings**
- **interface to allow simulations with NS-2**



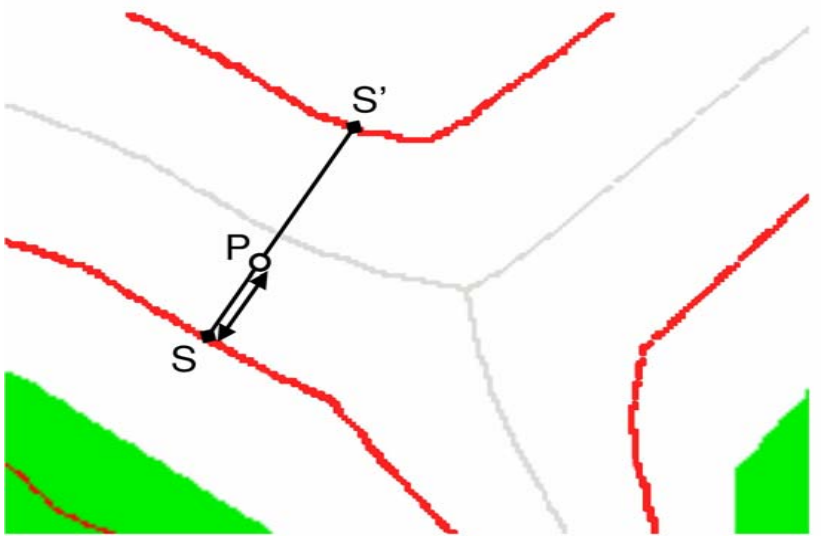
Voronoi graph of second order

Node Placement

- **the problem:**

  How to place a node P randomly on the field within movement channel?

- **our approach:**
  - **choose random point R on the first Voronoi graph**
  - **construct perpendicular line through R and cut with second order Voronoi graph in S and S'**
  - **place node P randomly on segment between S and S'**

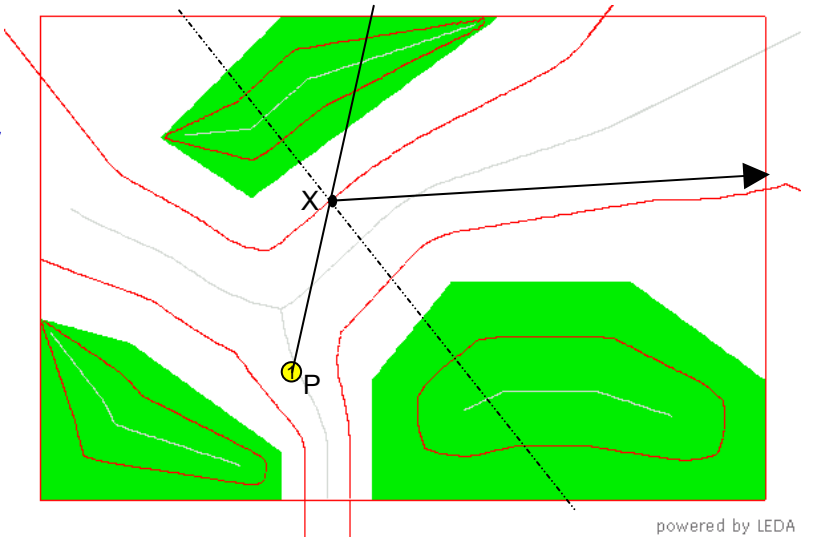


random node placement

Movement Calculation

each node

- **… is moving in an angle-defined direction α with a speed $v \in [v_{min}, v_{max}]$**
- **… when crossing channel border**
  - **is reflected with $P_{ch,thres}$**
  - **crosses border with 1-$P_{ch,thres}$**
- **… when crossing building wall**
  - **is reflected with $P_{wall,thres}$**
  - **crosses wall with $P_{wall,thres}$**
- **… is reflected when leaving simulation area**



movement of a node

… yet another Mobility Model?

Properties of Voronoi Mobility Model:

- **easy to handle**
- **generic approach**
- **more "realistic" than comparable models**
- **different user classes supported**

Voronoi Mobility Model does not prove general validity, but can help to show that general results are also valid in "realistic" environments.

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- **Part IV Conclusion**
  - **choosing the right Mobility Model**
  - **why still Mobility Modelling?**

Choosing the Right Mobility Model…

- A mobility model has to be adequate to the simulation's needs.
- Simulations have to be evaluated in a steady-state concerning node distribution and velocity distribution.
- Special attention has to be paid to the behaviour of the nodes at the borders of the simulation grid.
- Mobility can hide system aspects or system bugs.
- Mobility is the second step after static scenario is understood.

Why still Mobility Modelling?

Sophisticated technologies need sophisticated models.

It still makes sense to put effort in modelling mobility, as new technologies create new effects (e.g. higher transmission frequencies, adaptive antennas), which are not considered by state of the art models.

Literature

- **J.-Y. Le Boudec et al., "Perfect Simulation and Stationarity of Class of Mobility Models", IEEE Infocom, 2005 (Best Paper Award)**
- **T. Camp et al. "A Survey of Mobility Models for Ad Hoc Network Research", Colorado School of Mines, 2002**
- **Hans-Martin Zimmermann and Ingo Gruber, "A Voronoi-based Mobility Model for urban environments", European Wireless, 2005**