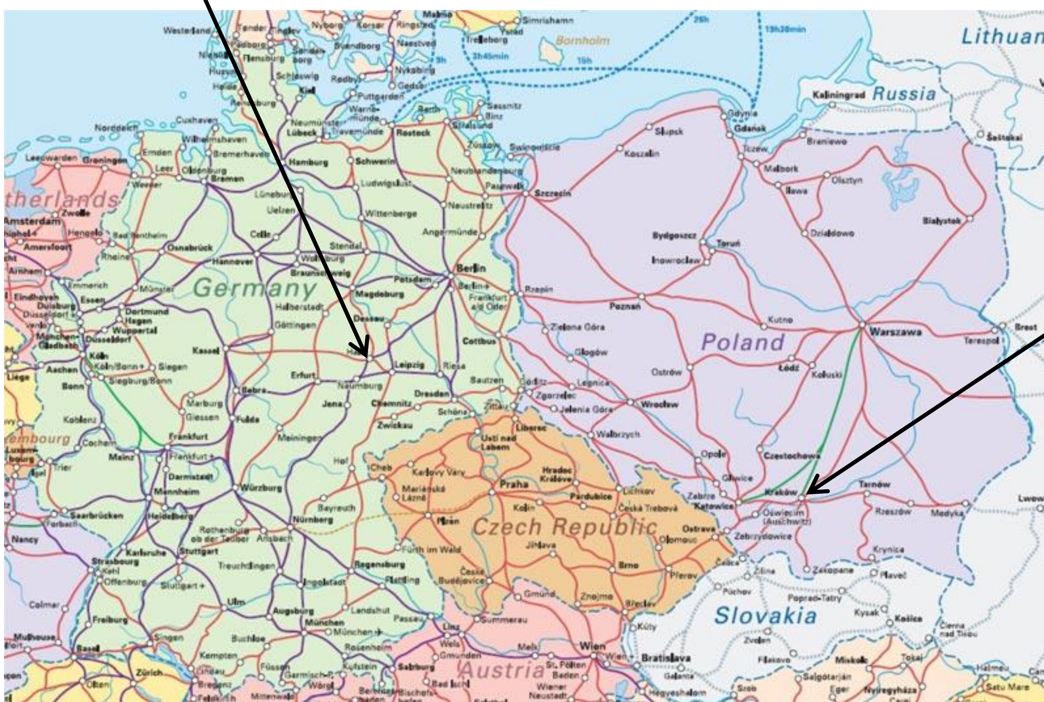
Collective map making

Janusz Malinowski, Małgorzata J. Krawczyk,
Przemysław Gawroński, Krzysztof Kułakowski
AGH – UST Kraków

Jan W. Kantelhardt

Halle University



2013 Summer Solstice

Discrete Models of Complex Systems

outline

- Selected precursors
- Motivation
- Idea, notation, aims
- Algorithm
- Results
- A comparison with random walk
- Conclusions

http://johnnygoodtimes.com/2008/06/around-the-horn-brought-to-you-by-robot-snakes/

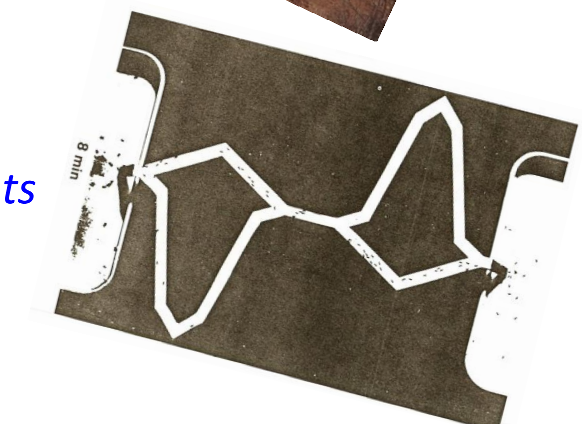
Selected precursors

1705 Bernard Mandeville, *Fable of the Bees*

„That strange ridic'lous Vice, was made
The very Wheel that turn'd the Trade. „

1959 Pierre-Paul Grassé, *Stigmergy*

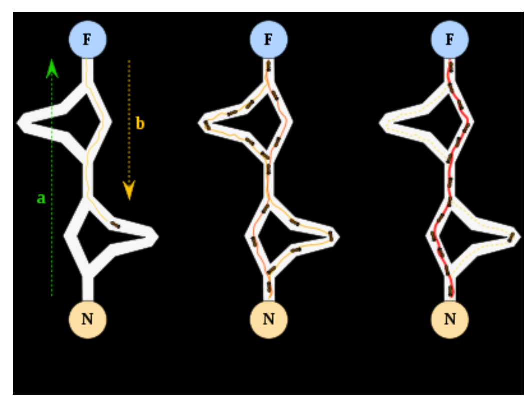
Individual parts of the system communicate
with one another indirectly
by modifying and sensing their local environment.



~1983 Jean-Louis Deneubourg, *experiments with Argentinian ants*

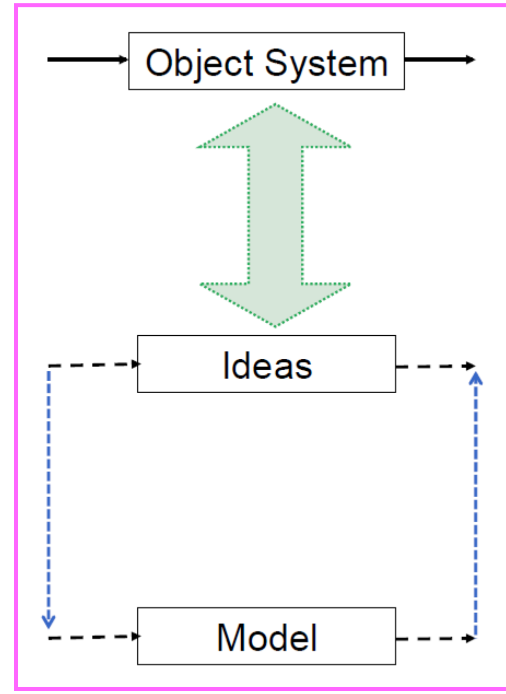
1986 Fred W. Glover, *Taboo search algorithm*

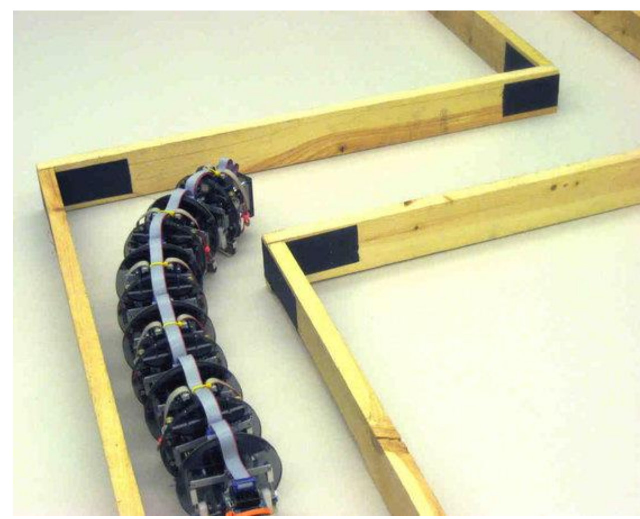
1991 Marco Dorigo, *Ant optimization algorithm*



motivation

http://www.sintef.no/home/Information-and-Communication-Technology-ICT/Applied-Cybernetics/Projects/SnakeFighter/





http://articles.philly.com/2011-07-11/news/29761520_1_autonomous-robots-humans-drexel-university

idea

Robots penetrate the labyrinth and remember the visited places.

When two robots meet, they share an information.

notation

T_1 – time when one (first) robot knows the whole labyrinth

T_2 – time when all robots know the whole labyrinth

N – size of the labyrinth (number of corridors)

W – number of robots

aims

What is the speed of penetration?

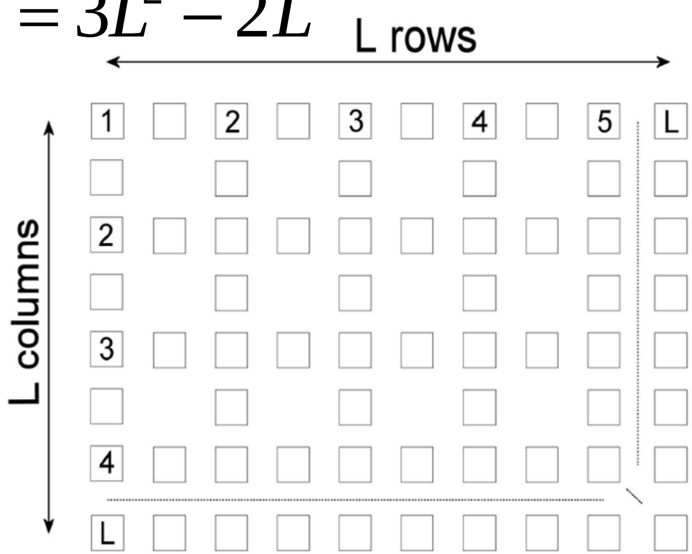
$$T_1(N,W) = ?$$

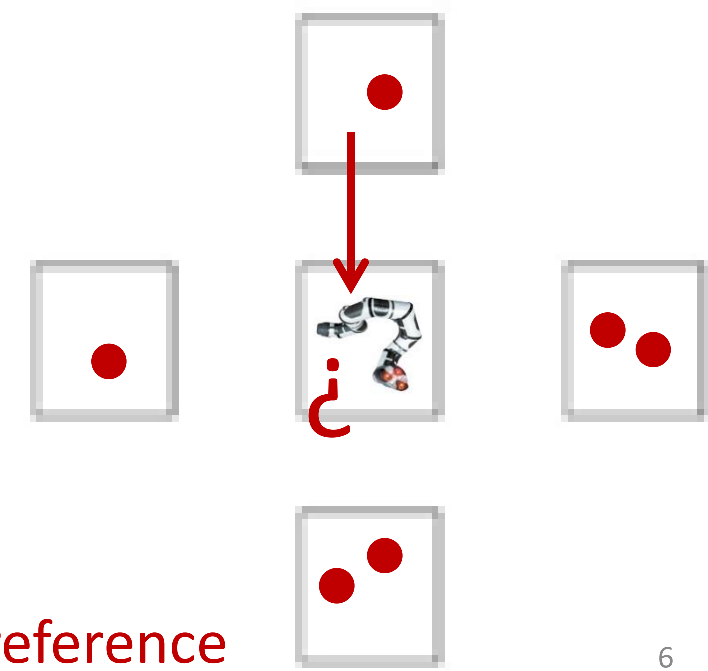
$$T_2(N,W) = ?$$

Algorithm

- Robots leave seeds at visited corridors.
- At a dead end robots leave two seeds.
- Two seeds are left in corridors visited again.
- Robots select corridors with minimal number of seeds, which demand minimal number of turns.
- A half of robots prefer to turn left, a half – to turn right.

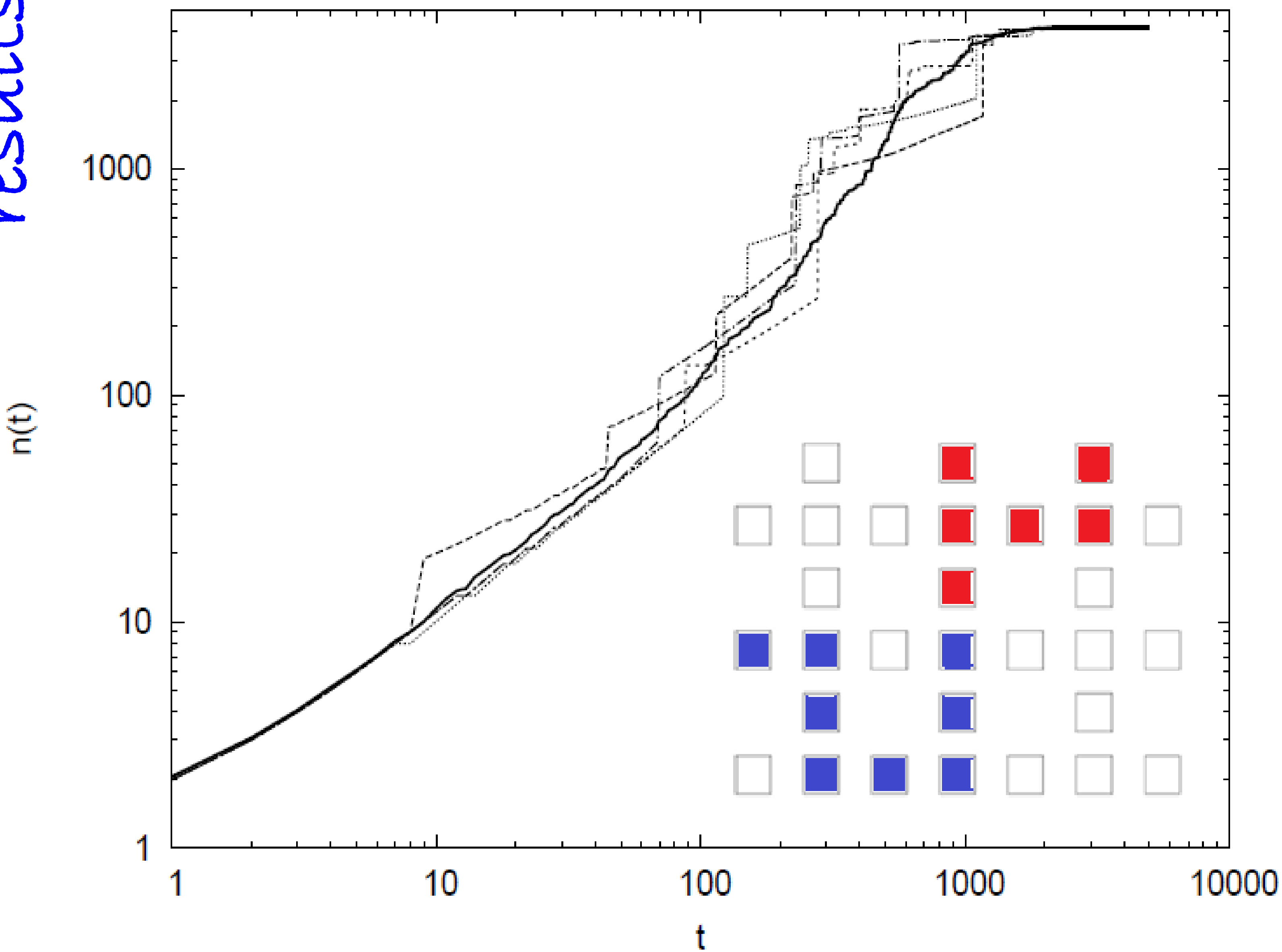
$$N = 3L^2 - 2L$$





An example: „left" preference

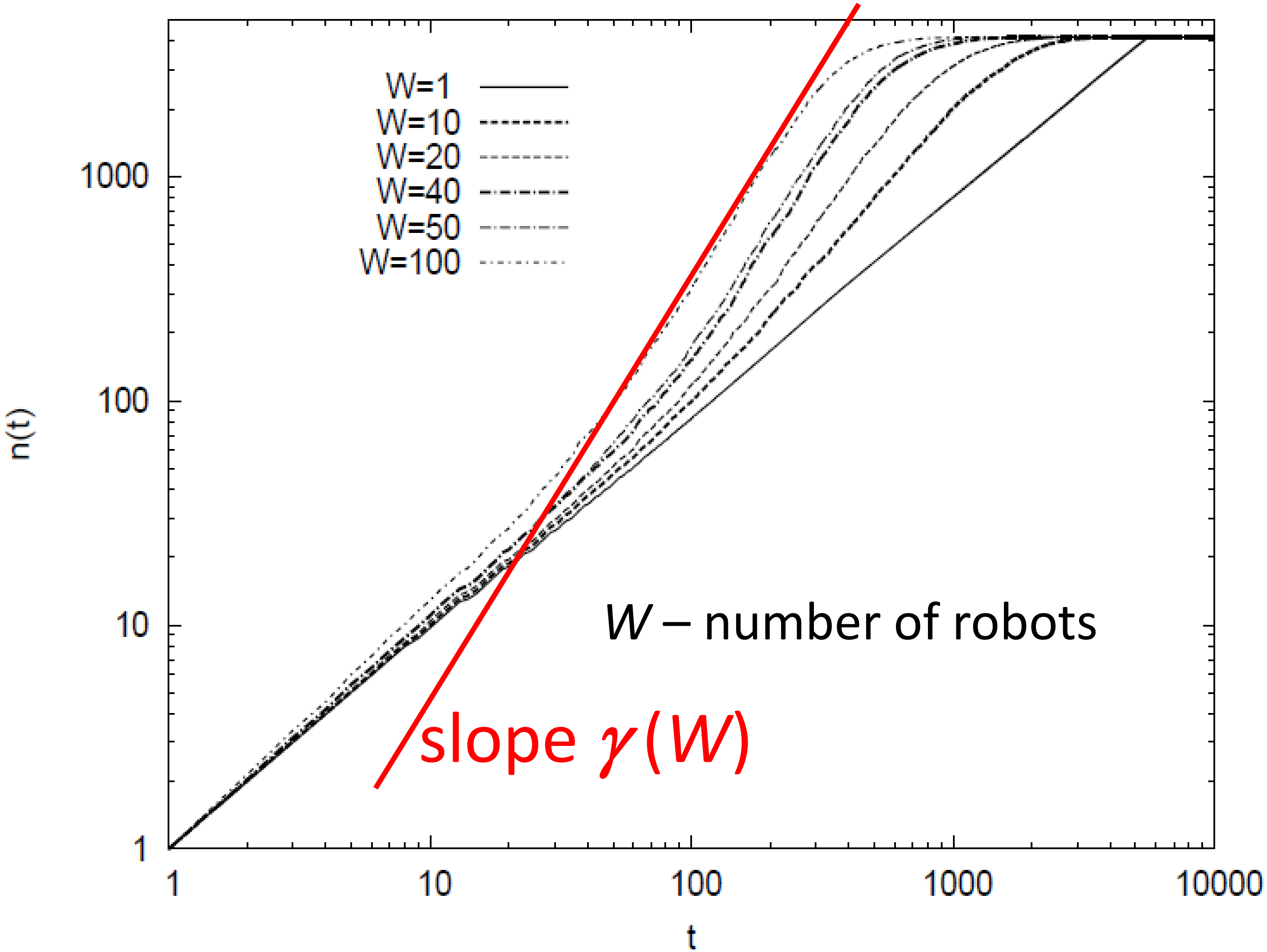
results



four dotted lines – four robots
solid line – average over 30 runs

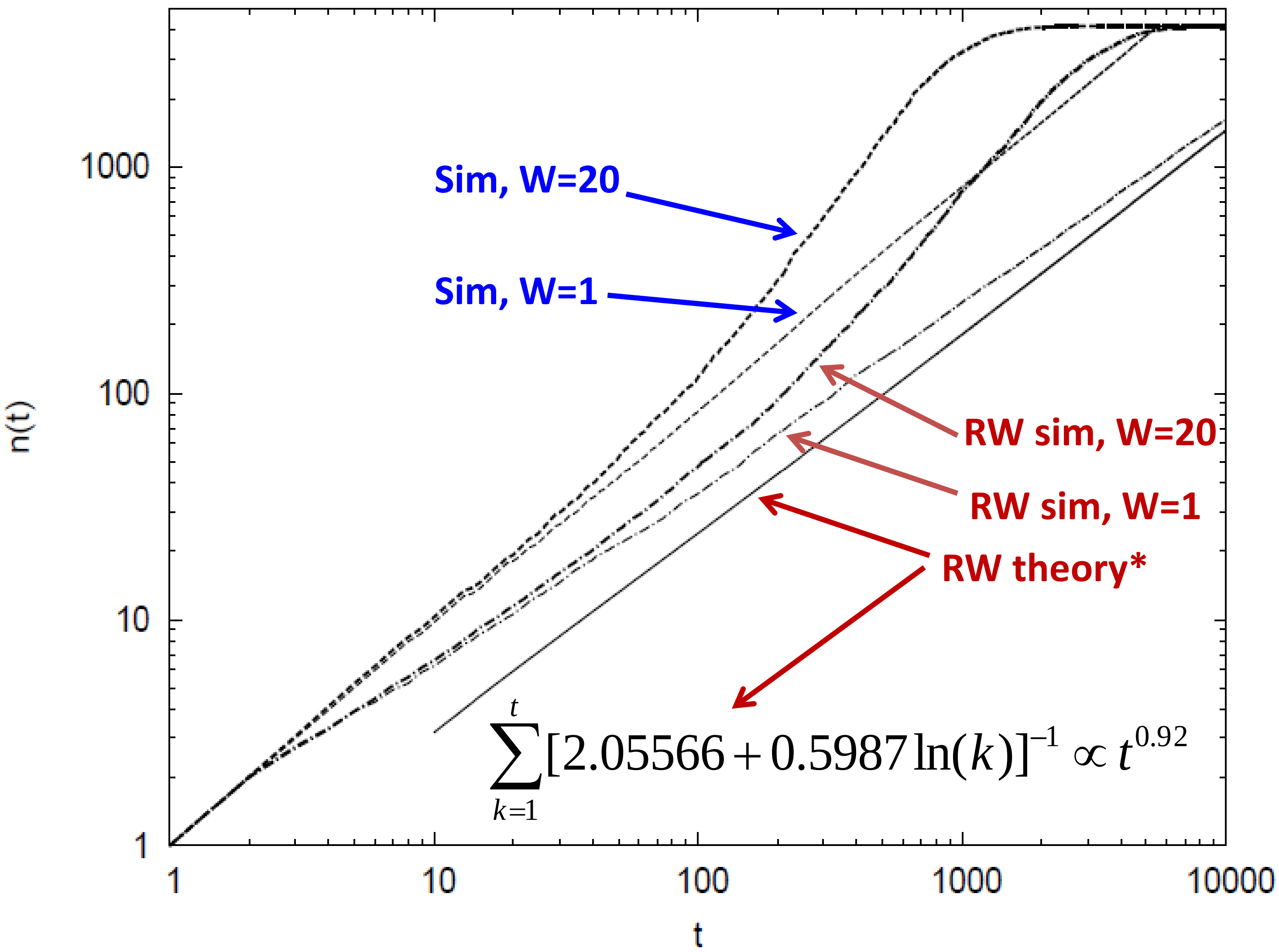
Number *n(t)* of different sites known in time *t* by one robot

results



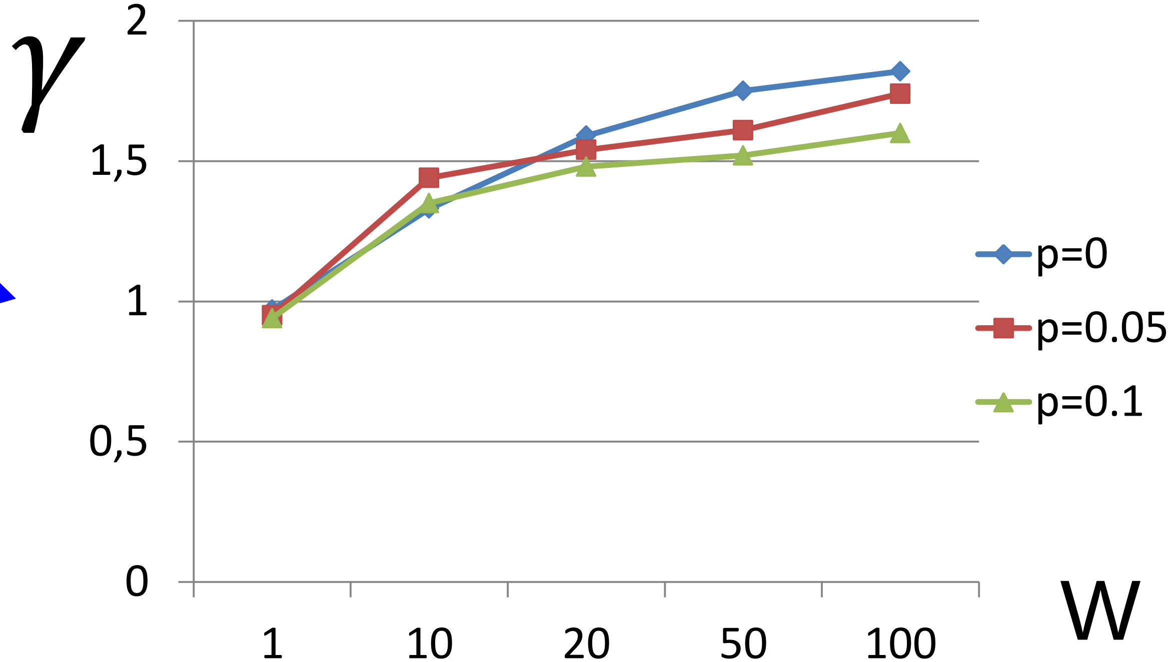
Time dependence of the number *n(t)* of different corridors known by one robot

results

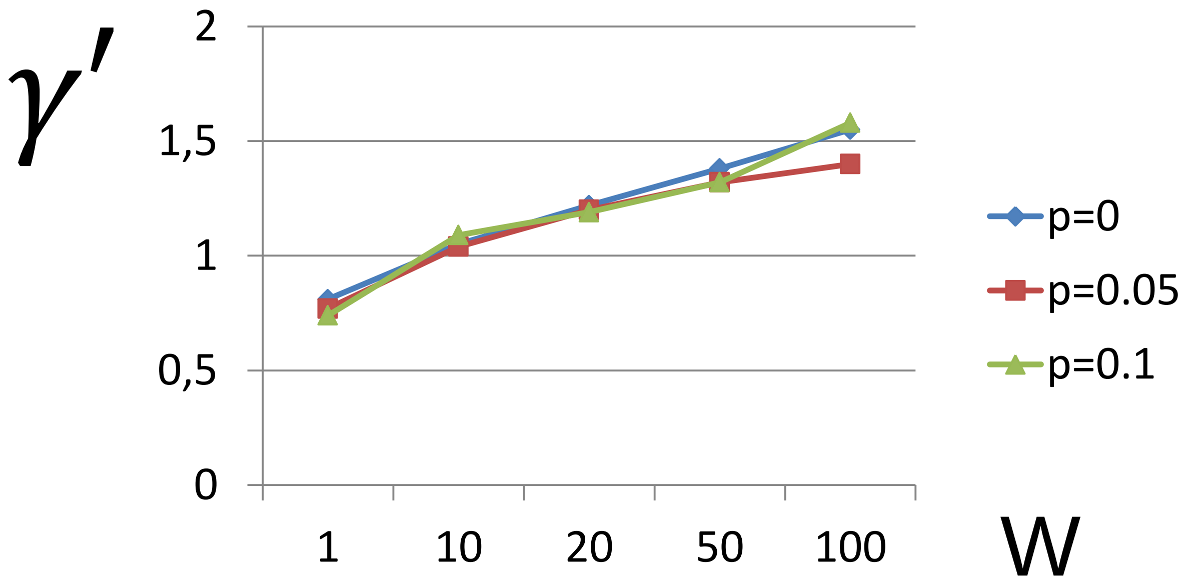


$$\sum_{k=1}^{t}[2.05566+0.5987\ln(k)]^{-1}\propto t^{0.92}$$

*F. S. Henyey and V. Seshadri, J. Chem. Phys. 76 (1982) 5530 deterministic



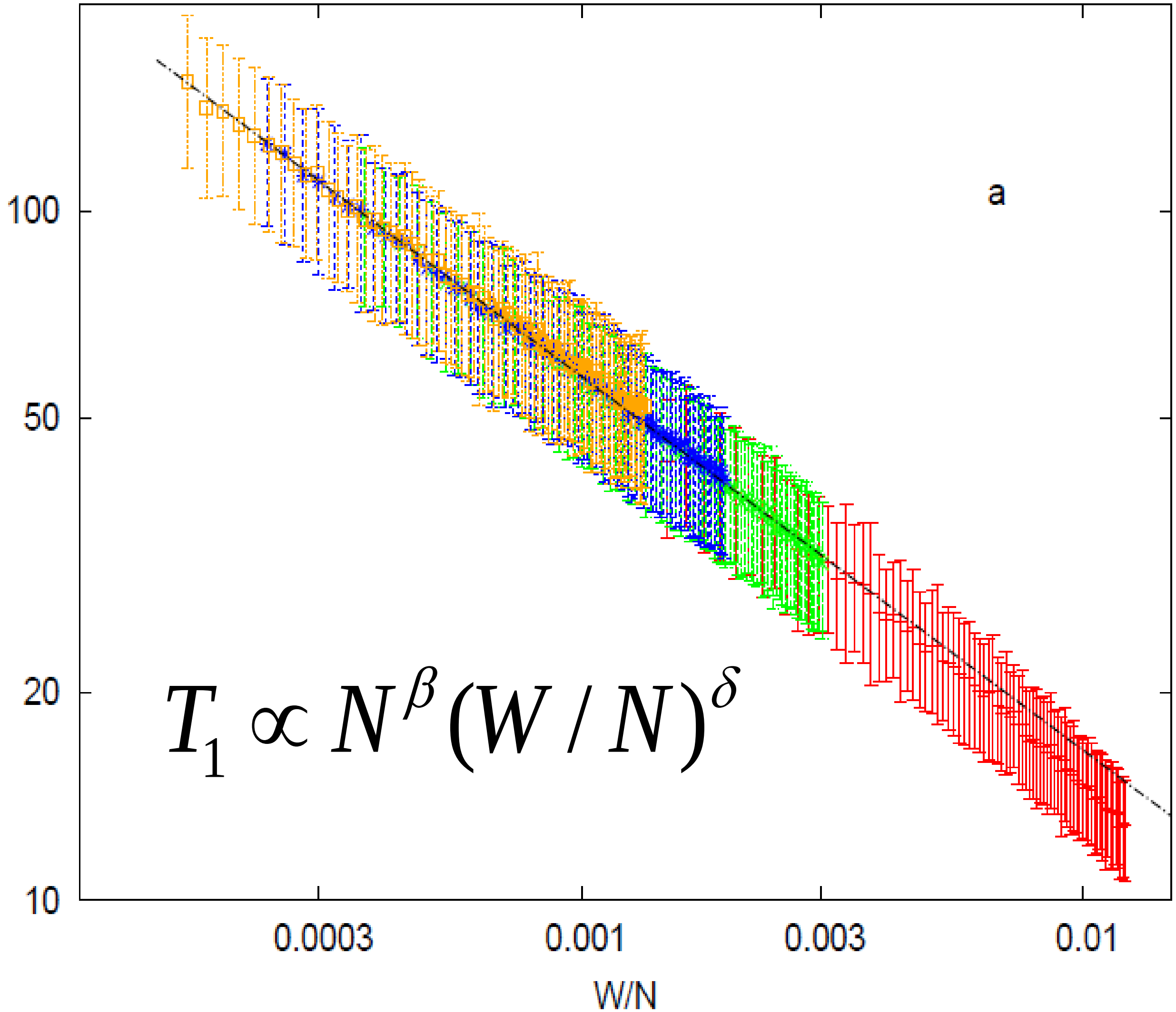
random walk



p -percentage of blocked corridors

Time T_1 when the first robot knows the whole labyrinth

results



$$T_1 \propto N^{\beta}(W/N)^{\delta}$$

$$\beta = 0.52$$

$$\delta = -0.54$$

$$\beta - \delta \geq 1$$

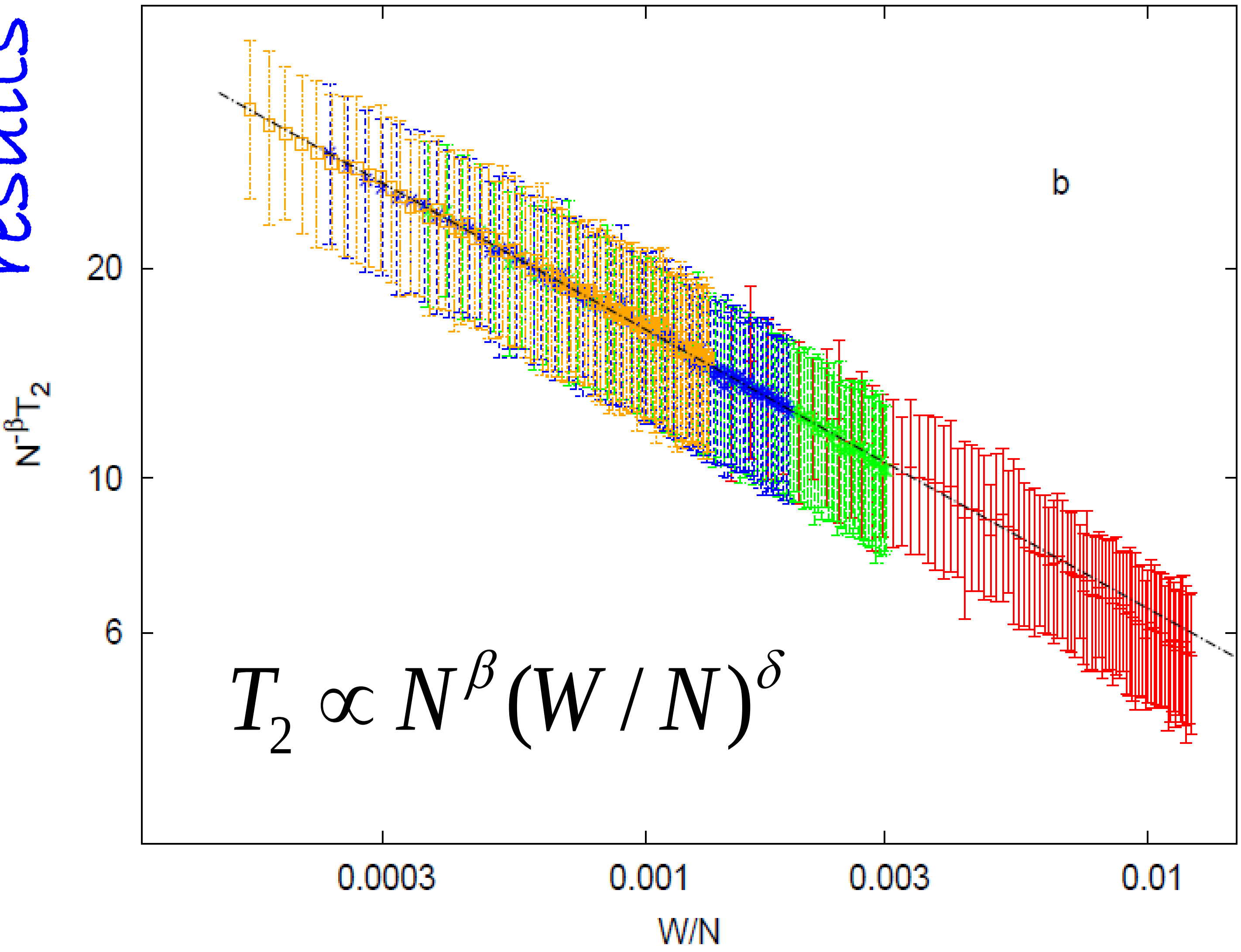
L=50, 100, 120, 150

W = 10,..., 90

= 500

Time T_2 when all robots know the whole labyrinth

results



$$T_2 \propto N^{\beta}(W/N)^{\delta}$$

$$\beta = 0.69$$

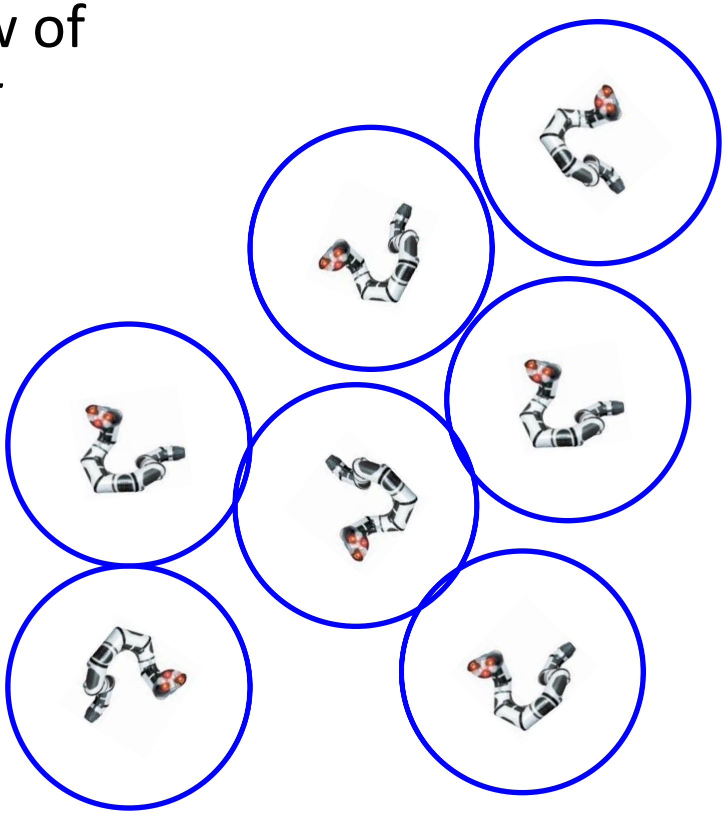
$$\delta = -0.40$$

$$\beta - \delta \geq 1$$

L=50, 100, 120, 150   W = 10,..., 90   # = 500

A trivially oversimplified approach

Individually penetrated areas spread as r^2, what is proportional to t (RW) or $t^{6/(d+2)}$ (Flory law of SAW), then collide at time T. Then, for $t < T$



RW≡SAW(d=4) **SAW** (d=2)

$$r^2 \propto t \qquad r^2 \propto t^{3/2}$$

where

$$T \propto (W/N)^{-1} \qquad T \propto (W/N)^{-2/3}$$

For $t > T$, $n(t) = N$

However, here we neglect the fact that the trajectories collide, and not the spheres. Also, they do not collide simultaneously.

A collision of trajectories in RW:
two Gaussians spread,
with initial distance $r = (N/W)^{1/2}$.
When they overlap? (their product $=p$)
Answer: $t \propto r^2$

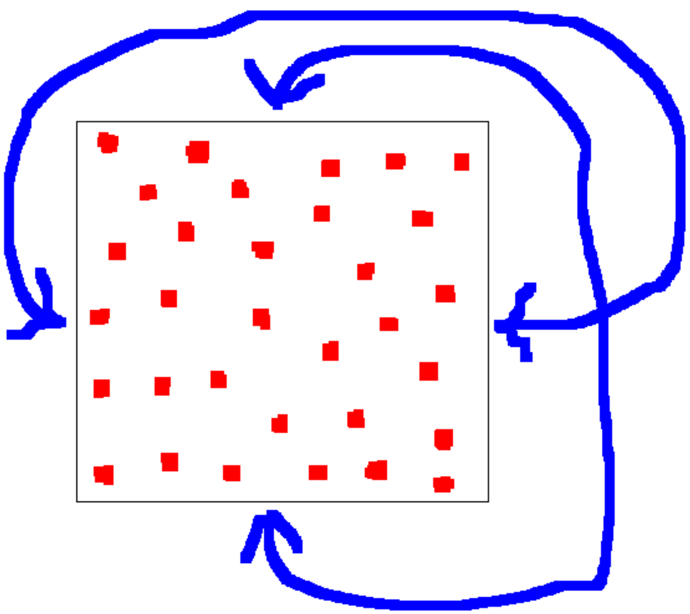
	β	δ
RW	0	-1
SAW	0	-2/3
T_1	0.52	-0.54
T_2	0.69	-0.4

conjecture

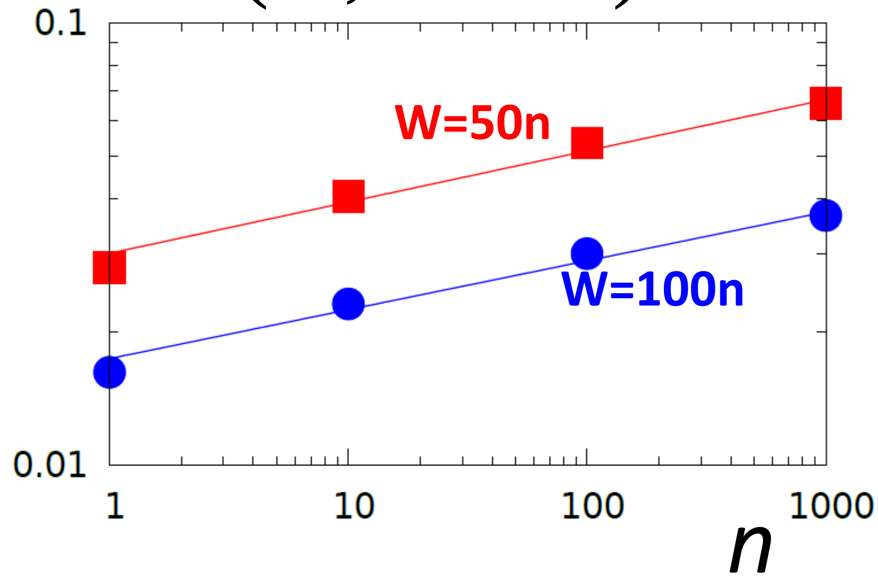
If the concept of spreading circles is appropriate, the exponent β for T_2 should be related with the extremal fluctuations of the initial density.

test

Points are randomly distributed in a plane, with constant density *W/N.*
How does the maximal distance between the points scale with the system size?



$$d^2_{\max}(W, W \propto N)$$



=100, 1000

$$d^2_{\max} \propto W^{0.11}$$

i.e. much slower than T_2

conclusions

The problem seems new and interesting.
For details see Malinowski ea, IJMPC 24 (2013) 1350035

The time of penetration scales with the robot density and with the system size.

The exponent β cannot be derived just from the density fluctuations. Hence the condition of colliding trajectories contributes to β.

Thank you