New Frontiers in Expertise

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Expertise

- An area less studied in psychology of learning and education
- Original ideas from Simon, Eriksson and Gobet still pivotal
  - 50K chunks (now 300K) or 10,000 hours of practice
  - Patterns are the key – but what are the?
- Games have been a big focus (especially Chess)

Methodologies

- Psychological experiments and braining imaging
- Data mining of real world decisions
- New focus on the Game of Go (computers still useless)

Transitions to Highest Level

- Established for Go (but very general ideas)
  - Local-Global at 1 Dan Amateur
  - Phase Transition at 1 Dan Professional
- Reorganisation of perceptual templates
- Need to test generalisation to other domains
- Profound implications for education and training

Towards measuring/evaluating adaptiveness in Multi-agent systems

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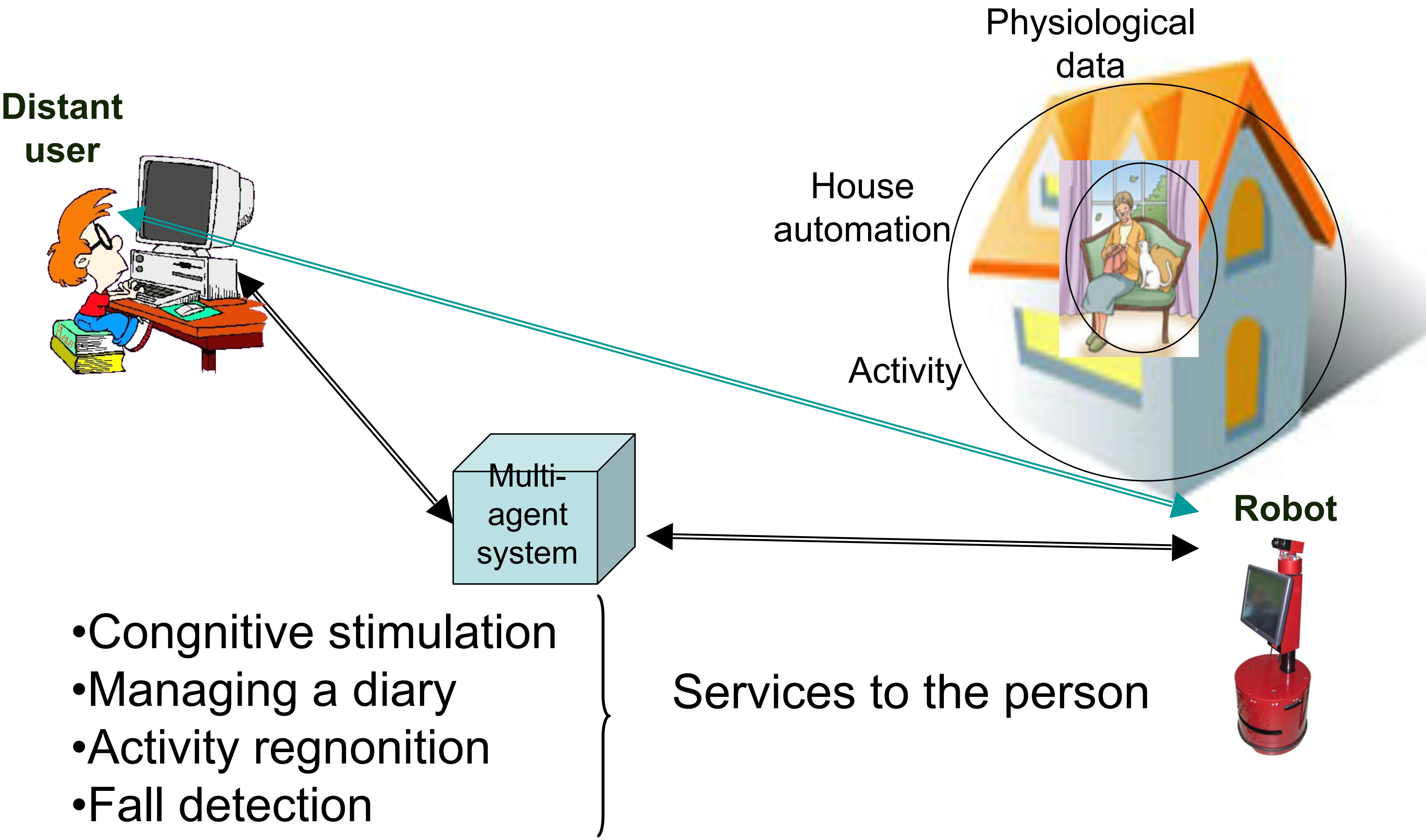
Ambient Assisted Living application



Question 1: does such a system need adaptation mechanisms?

Adaptiveness of an ambient assistive system

How many important aspects of an adaptive ambient assistive system it supports?

- Computational features
- Methodological features
- Functional features
- Ethical features

Question 2: are there any other features?

Adaptation evaluation/measuring

Evaluation/measuring is the systematic determination of merit, worth, and significance of something.

Question 3: Based on what to adapt?

Question 4: When and how to adapt?

Question 5: What level of user control when adapting?

Measuring Perceived Adaptiveness in a robotic eldercare companion

http://dare.uva.nl/document/117902

- Perceived Adaptiveness (acceptance methodology)
- Perceived Usefulness

Question 6: is it possible to design systems that are able to reason about their own adaptiveness?

- Measure the adaptation complexity effectively is an open issue in natural or artificial systems
- Some essential characteristics of adaptation in evolvable systems and the importance/complexity of constructing multi-objective fitness functions in evolutionary computation are analyzed

Adaptive Fractal-like Network Structure for Efficient Search of Targets at Unknown Positions

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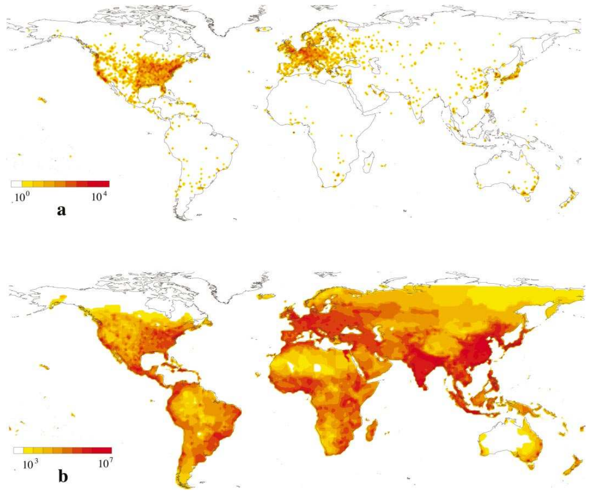
1. Spatial Distribution of Nodes

Many real networks are embedded on a metric space, there exist dense and sparse areas. ⇒ Non-Poisson !

Router (top) and population (bottom) density maps



S.H.Yook, H.Jeong, A.-L.Barabási, PNAS 99(21), 13382, 2002.

Similar in transportation and mobile comm. nets

R.Guimerá et al. PNAS 102(22), 7794, 2005, & R.Lambiotte et. al. Physica A 387, 5317, 2008.

Objective: adaptive search

We focus on a self-organized network infrastructure by taking into account realistic spatial distributions of nodes and communication requests, though regular lattices or random graphs on a homogeneous space have been tacitly assumed in many cases of the conventional models.

In particular, we are interested in a relation of the optimal search and the routing on a spatially inhomogeneous network structure according to a population.

2. Biological Foraging

Animals move from a place to other place in order to eat and mate, and to escape their predators.

The behavior of stay-around $\leftrightarrow$ travel $\neq$ u.a.r flight

Science 318(11), 742-743, 2007

in honey bees, desert ants, butterflies, snails, sharks, gray seals, penguins, deer, jackals, spider monkeys, albatrosses, dollar bills, and GPS tracking of humans.

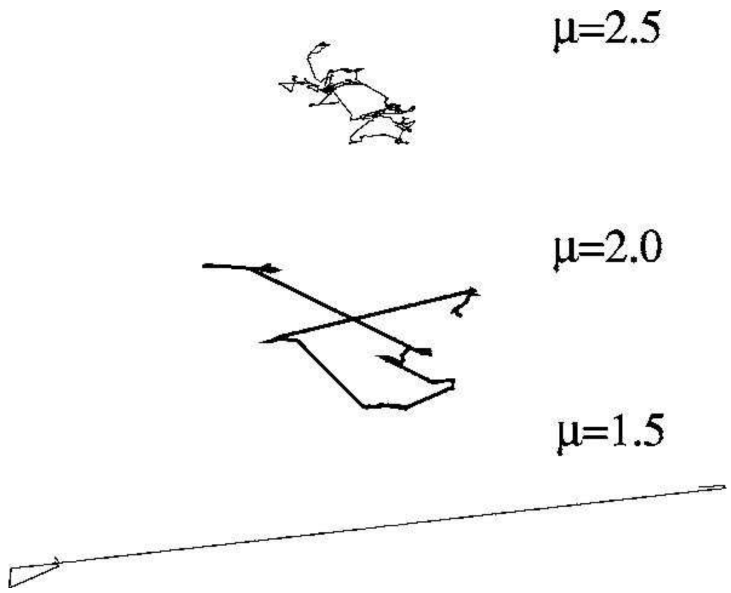
G.M.Viswanathan et al. The Physics of Foraging, Cambridge Univ. Press, 2011.

Optimal Search

The probability of flight length follows

$$P(l_{ij}) \sim l_{ij}^{-\mu}$$

from ballistic ($\mu \rightarrow 1$) to Brownian motion ($\mu = 3$).

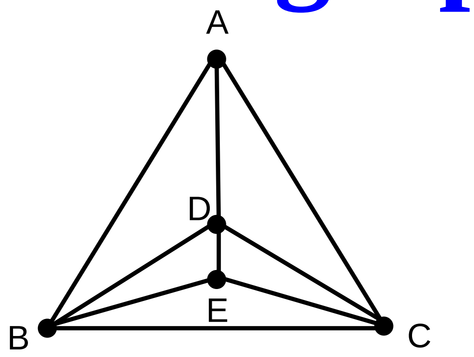


The Levy flight of $\mu \approx 2$ is optimal for sparsely and randomly located targets in a continuous space model and in a 2D lattice model.

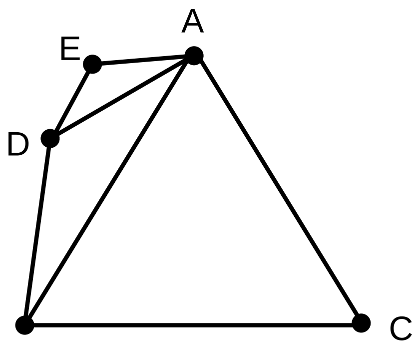
G.M.Viswanathan et al. Nature 401, 911, 1999, & M.C. Santos et al. PRE 72, 046143, 2005.

$\Rightarrow$ It is unknown for inhomogeneously distributed targets ?

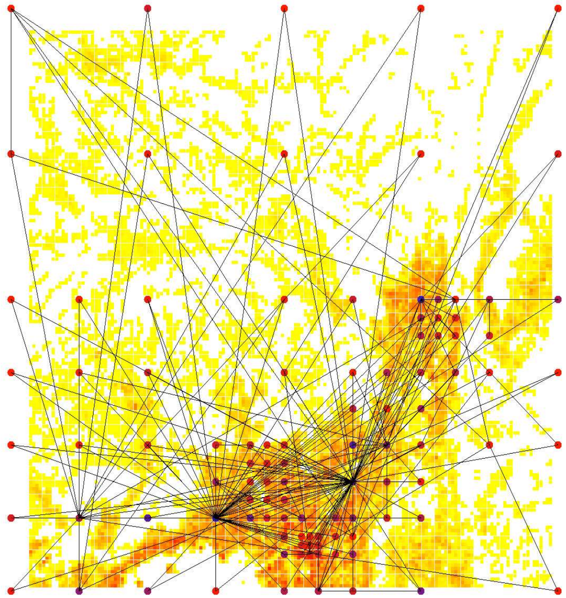
3. Geographical Networks



(a) Random Apollonian Net



(b) Random Pseurdofractal SF Net



(c) Geo. BA-like Net

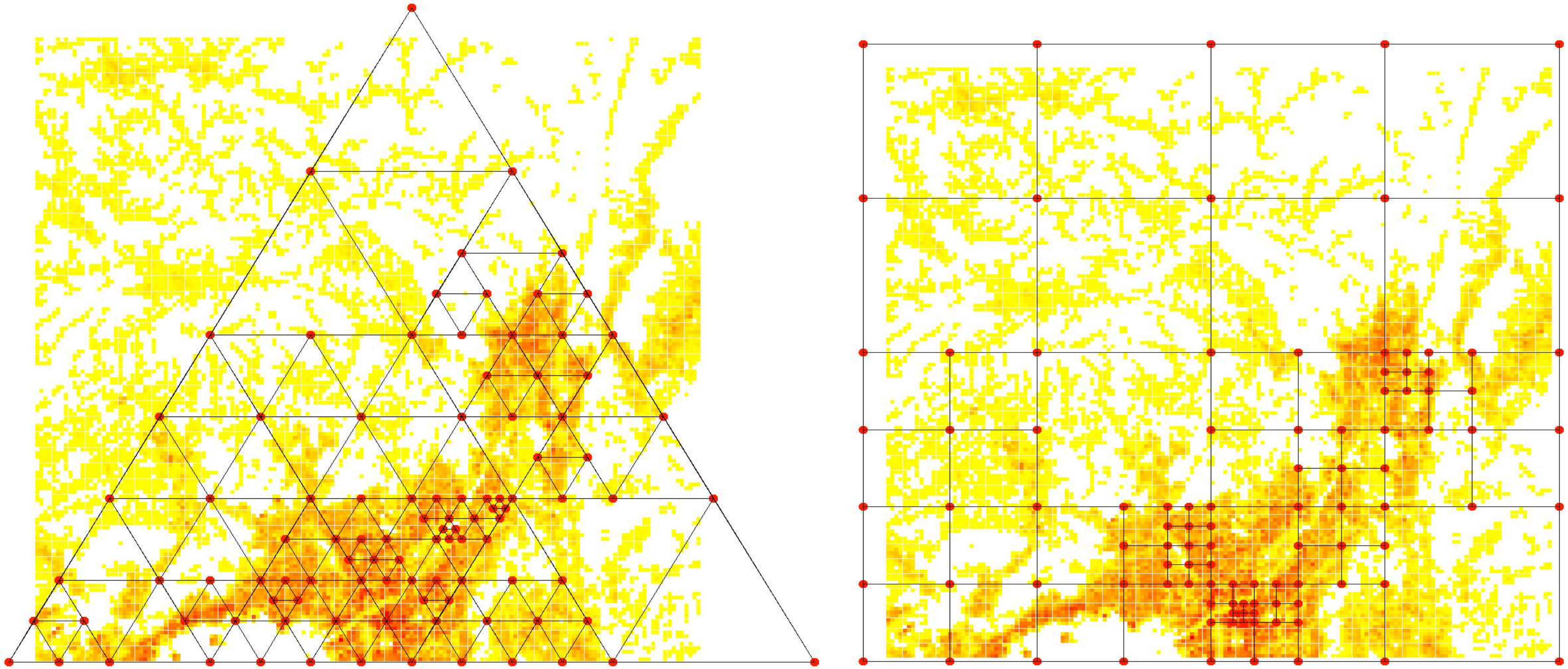
(c) Spatial preferential attachment to node i:

$\Pi_i \sim d_{it}^{\beta} k_i^{\gamma}$, for generating from river to SF networks

$\exists$ Long-range links, & vulnerability against attacks

Multi-Scale Quartered Net

From an initial configuration, at each time step, a face is chosen with a probability. Then, four smaller faces are created as a self-similar tilling.



$k_1 = 2$, $k_2 = 4$(Tri) or 3(Squ), $k_3 = 6$(Tri) or 4(Squ).

Good Properties of MSQ Nets

- Trimodal low degrees suitable for the tolerant connectivity against both failures and attacks
- Bounded short path as the t-spanner with the stretch factor $t = 2$
- Efficient decentralized routing on the planar network (without crossing links that cause the interference of wireless beams)

Compared to other geographical scale-free networks

Y.Hayashi, Physica A 388, 991, 2009, & PRE 82, 016108, 2010.

However, the position of a new node is restricted in the half-point of an edge of the chosen face.

$\Rightarrow$ Generalization from divisions of square to ones of rectangle, in order to set a node at any position

Preferential Routing

Decentralized α-random walk:

The forwarding node j is chosen proportionally to

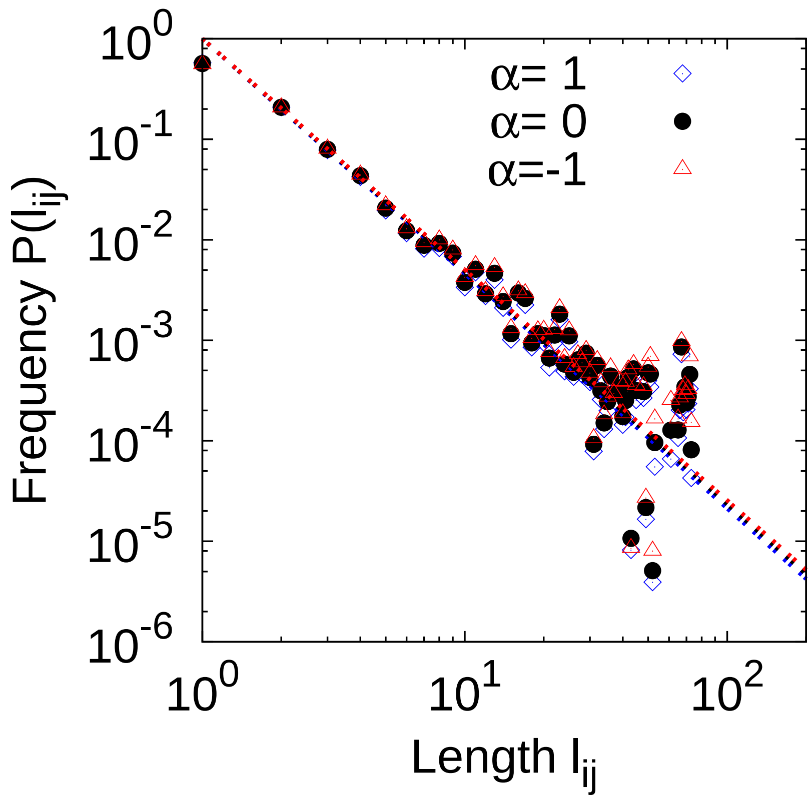
$$\frac{K_j^{\alpha}}{\sum_{j' \in \mathcal{N}_i} K_{j'}^{\alpha}}$$

in the neighbors $\mathcal{N}_i$ of its resident node i, where K_j denotes the degree of node j.

A larger degree node tends to be chosen for $\alpha > 0$: short(min-hop) path via a hub, while a smaller degree node for $\alpha < 0$: avoiding congestion, in general.

4. Simulation Results

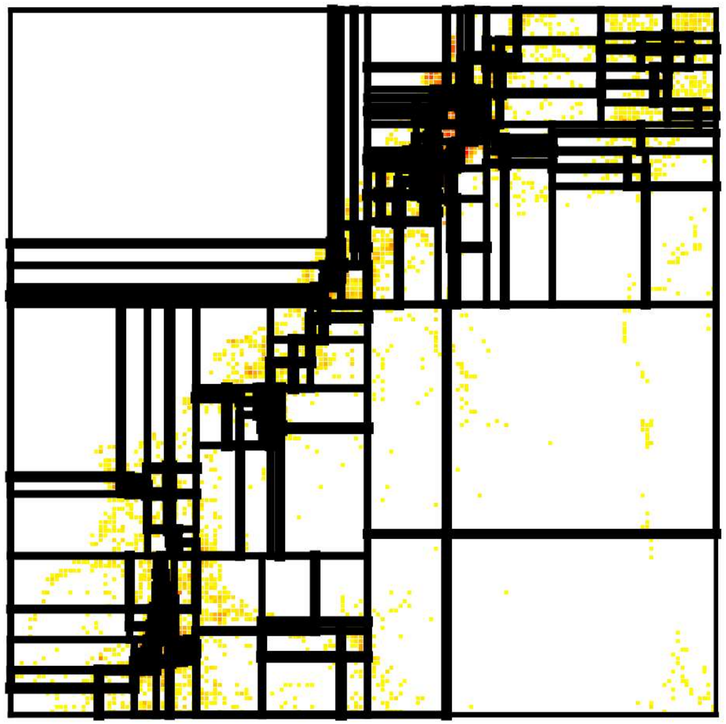
Length distribution of visited links on generalized MSQ networks by an α-random walker in 10^6 steps.



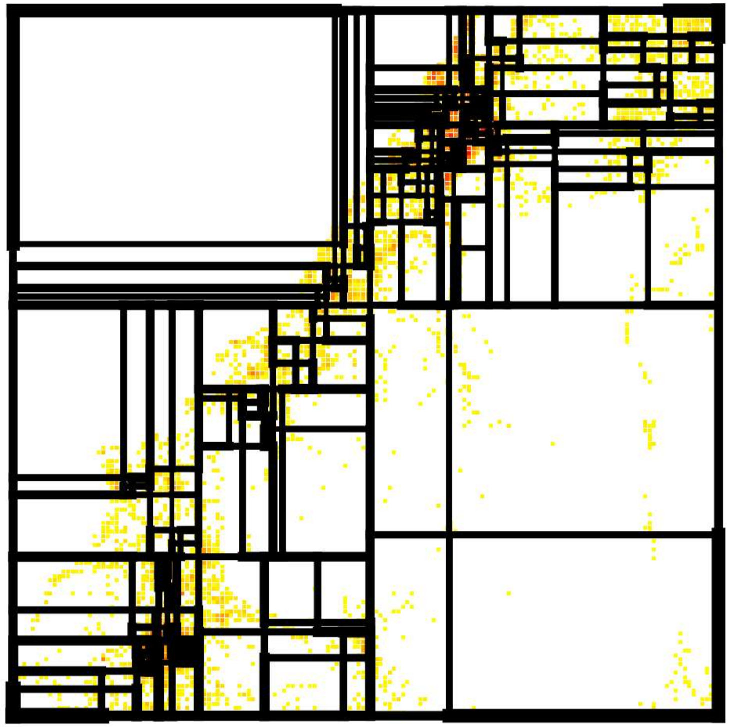
The dashed lines suggest $P(l_{ij}) \sim l_{ij}^{-\mu}$ with $\mu \approx 2.3$, which is comparable to a Levy flight $(1 < \mu \leq 3)$.

Basic Property

Frequency of Visited Links



Diagonal: $\alpha = +1$

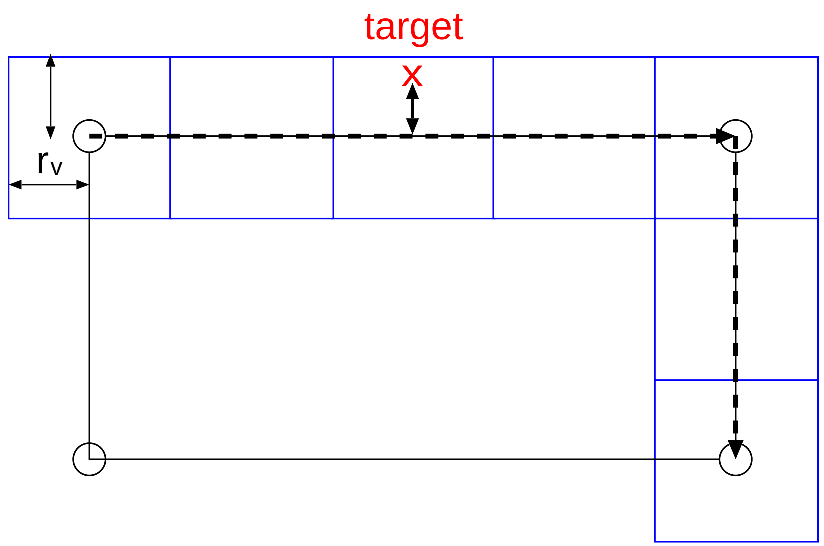


Peripheral: $\alpha = -1$

The difference appears even for the degrees 2,3, and 4 in a G-MSQ network.

For Created/Removed Targets

A walker constantly looks for targets scanning within the vision area of r_v hops.
After a detection, the direction is changeable in Levy flight on the lattice, while it's only at a node along the edge in α-random walk on the G-MSQ net.

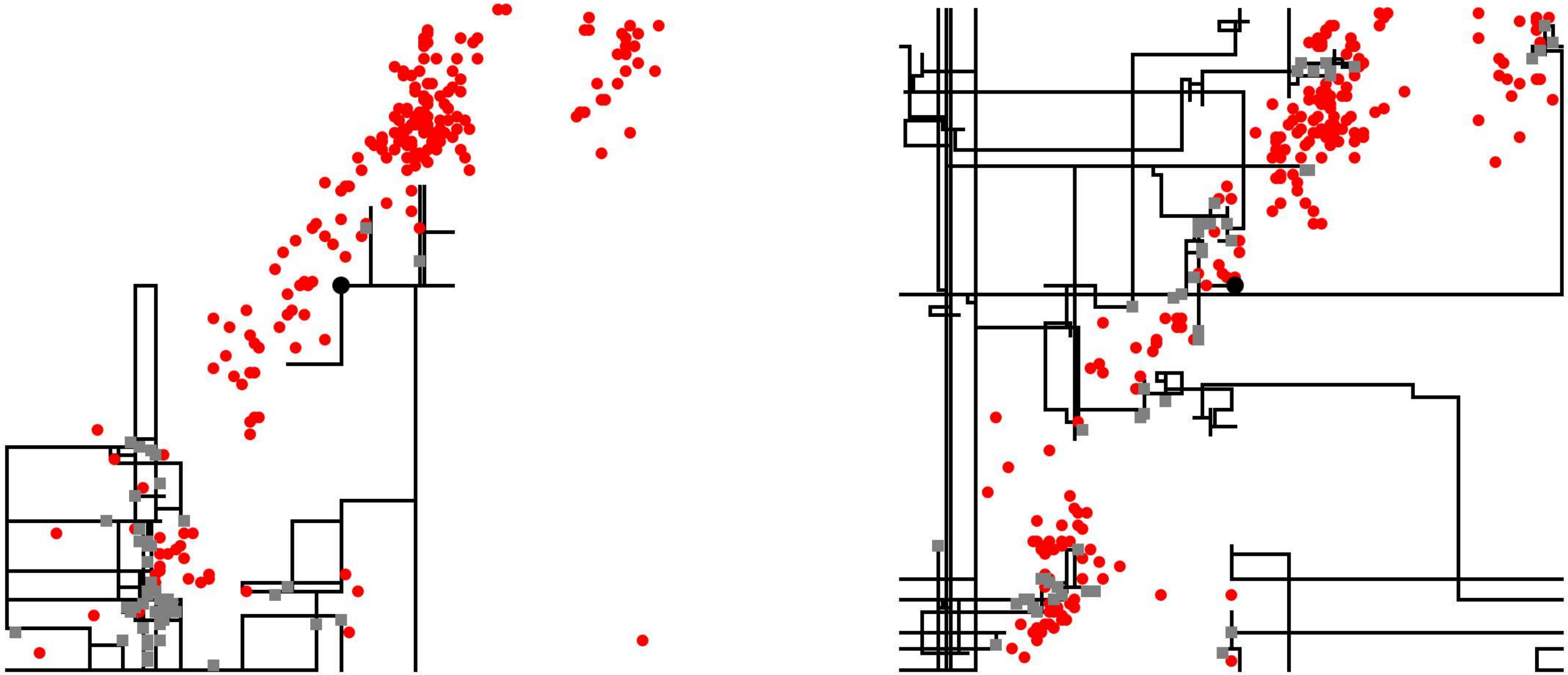


$$\eta \stackrel{\text{def}}{=} \frac{1}{M} \sum_{m=1}^{M} \frac{N_s}{L_m},$$

$$\lambda \stackrel{\text{def}}{=} \frac{(L+1)^2}{N_t 2 r_v},$$

L_m: traversed hop-distance until detecting N_s targets in the m-th trial, λ: mean interval between two targets in the total N_t on a $L \times L$ square lattice

Inhomogeneous Search

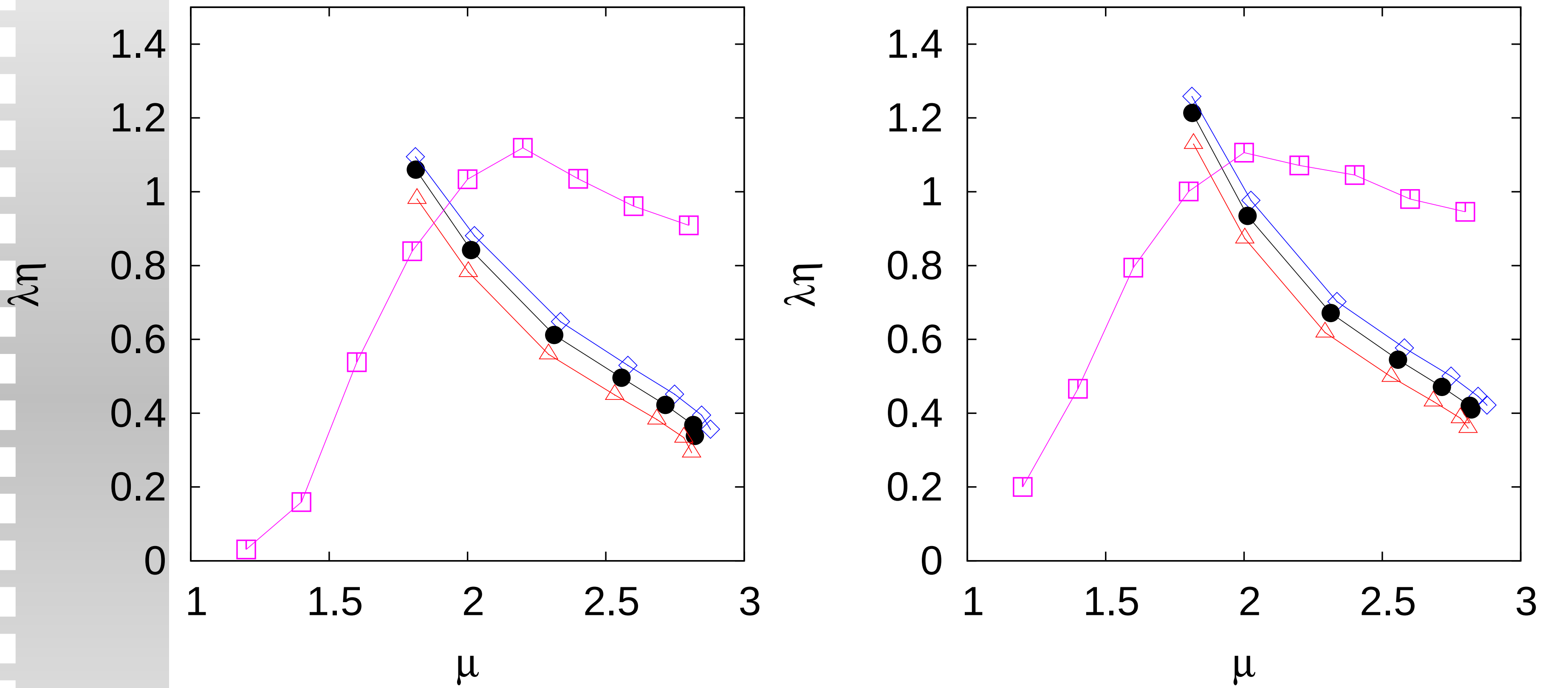


$\alpha = 0$ walk on G-MSQ, adaptive to diagonal area

Levy flight on the latice, wandering the whole

until detecting $N_s = 50$ targets in $N_t = 200$

Scaled efficiency by density



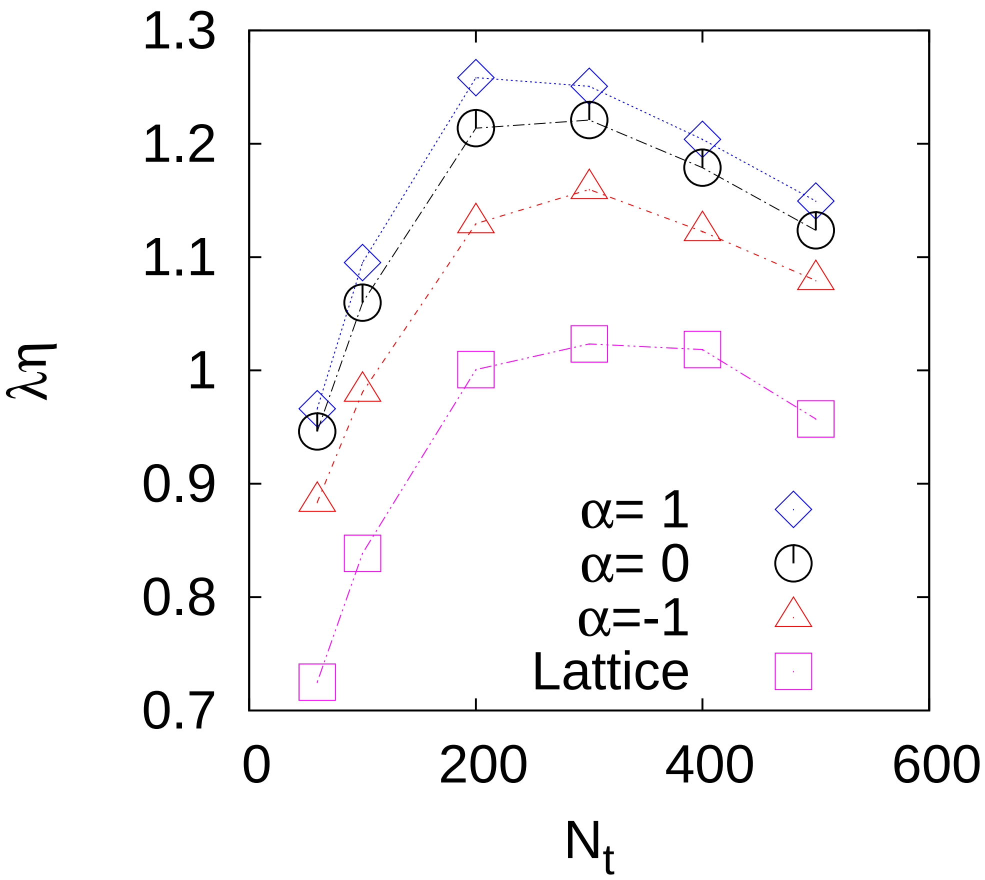
$N_t = 100$ $N_t = 200$

Levy flight: □, G-MSQ: △, ○, ◇ for $\alpha = -1, 0, +1$.

($N = 500, 1000, 2000, 3000, 4000, 5000$, and N_{max}).

Peak of Efficency $\lambda\eta$ for N_t

We further investigate the part of sticking-out, for varying N_t at the section of $N = 500$ in G-MSQ net and of the corresponding $\mu = 1.8$ in Levy flight.



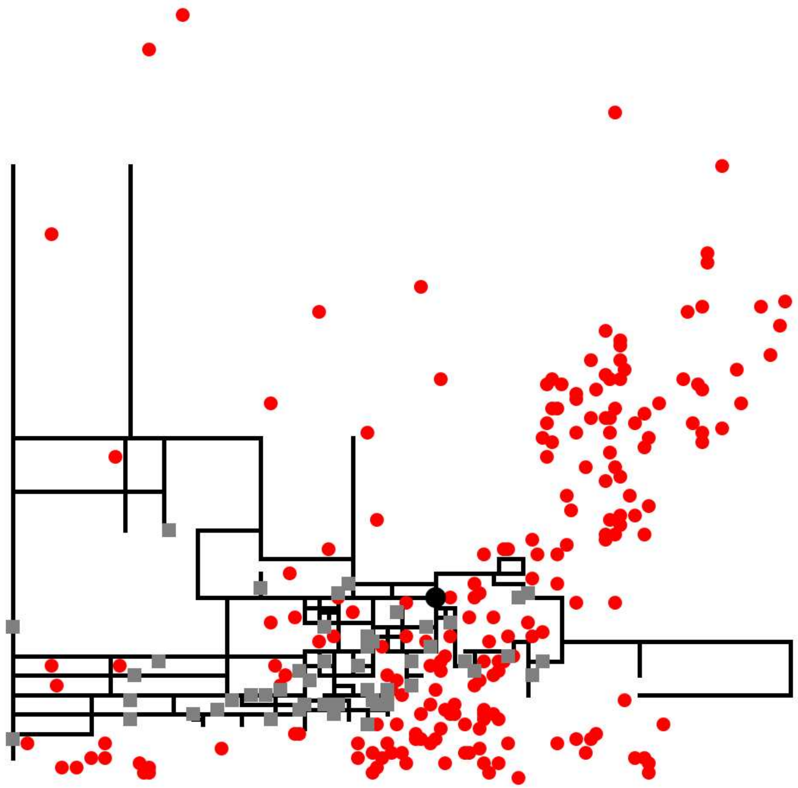
5. Summary: anisotropic cover

From viewpoints of CNS and BF,

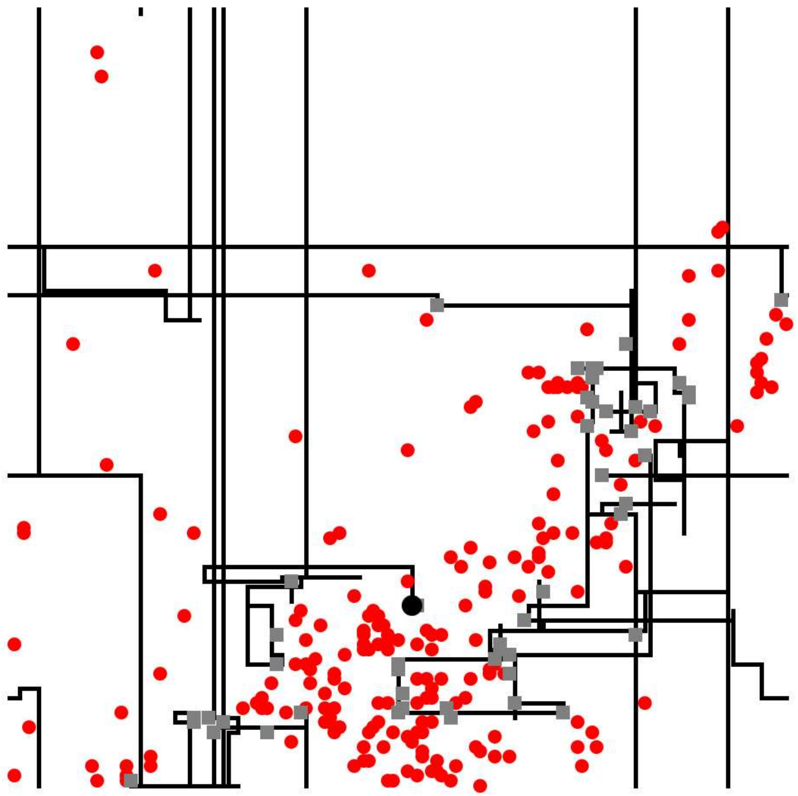
- We propose a scalably self-organized geographical network by iterative divisions of rectangles for load balancing of nodes in the adaptive change of their territories.
- The frequency of visited links by an α-random walk on the network suggests a power-law, which is comparable to the Levy flight.
- For inhomogeneously distributed targets, the adaptive search on the naturally embedded fractal-like network by population shows higher efficiency than the conventionary optimal Levy flight on a lattice, especially in the small $N = 500$ and the moderate $N_t \approx 200$ of targets.

Appendix 1.

Weak effect in other case with more homogeneously distributed targets (proportionally to population)

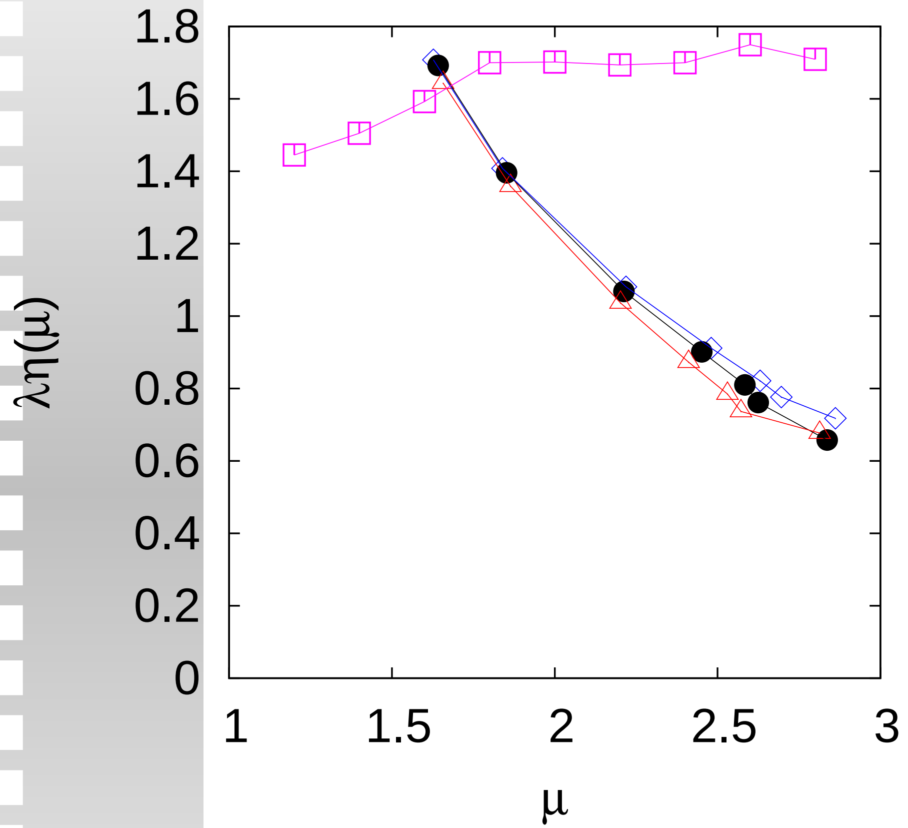


$\alpha = 0$ walk on MSQ net

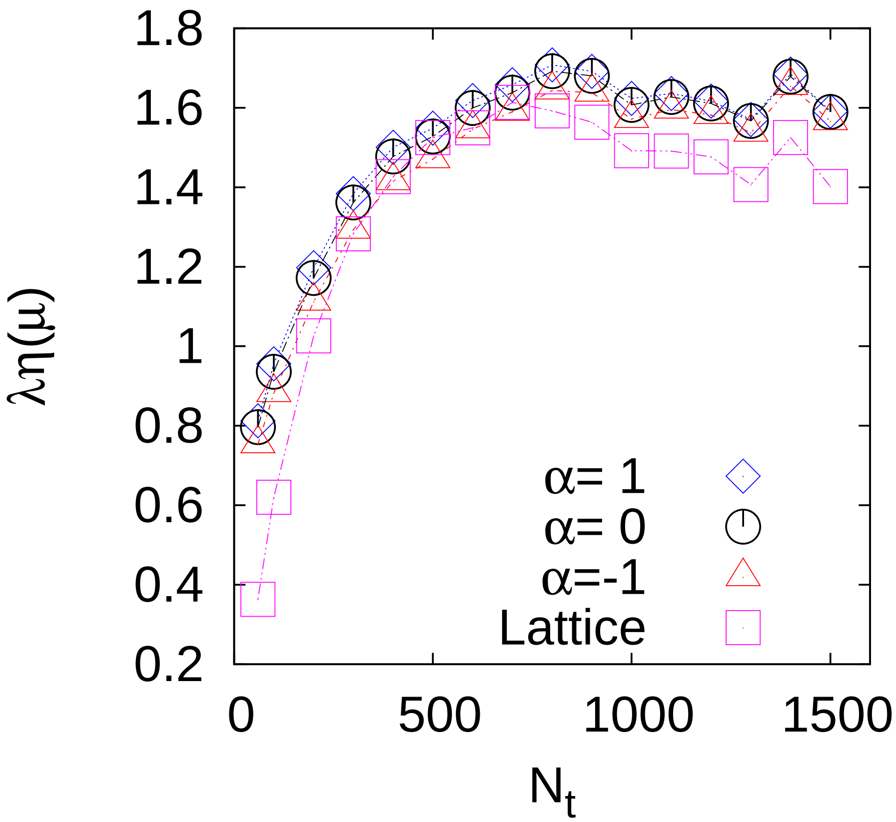


Levy flight on the latice

Appendix 2.



$N_t = 800$



Peak of $\lambda\eta$ for N_t

Levy flight: □, G-MSQ: △, ○, ◊ for $\alpha = -1, 0, +1$.

($N = 800, 1000, 2000, 3000, 4000, 5000$, and N_{max}).