Dynamic models of Gentrification

Giovanni Mauro, Nicola Pedreschi, Luca Pappalardo, Renaud Lambiotte

Consiglio Nazionale delle Ricerche

University of Oxford

Università di Pisa

KDD Lab

Scuola Normale Superiore

Università degli Studi di Bari Aldo Moro

Gentrification

"**One by one**, many of the **working class quarters** of London have been **invaded** by the middle classes – upper and lower (…)
Once this process of **'gentrification'** starts in a district it goes on **rapidly** until all or most of the original **working** class occupiers are **displaced**" (…)

Ruth Glass, 1964

What is Gentrification?

"The process of **improving** an area of a town or city so that it attracts people of a **higher** social class than before"

Oxford Advanced Learner's Dictionary

"The process by which a place, especially part of a city, changes from being a **poor** area to a **richer** one, where people from a higher social class live"

Cambridge Dictionary

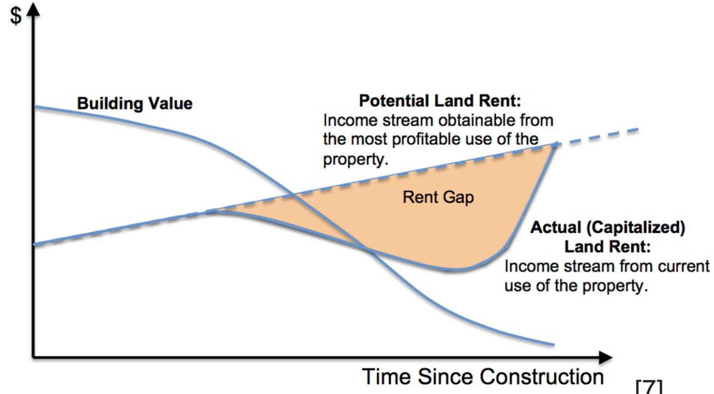
How to measure Gentrification?

- "Measuring the invisible" [1]
  - Replacement or displacement?
  - Do we even have correct data?
    - Hard to retrieve them [2]
- We need a Digital Twin (*of data that does not exist*!)

[1]Atkinson, R. (2000). Measuring gentrification and displacement in Greater London.
[2] Easton, S., Lees, L., Hubbard, P., & Tate, N. (2020). Measuring and mapping displacement: The problem of quantification in the battle against gentrification.
[3] Wachsmuth, D., & Weisler, A. (2018). Airbnb and the rent gap: Gentrification through the sharing economy.
[4] Zukin, S., Lindeman, S., & Hurson, L. (2017). The omnivore's neighborhood? Online restaurant reviews, race, and gentrification.
[5] Bunten, D. M., Preis, B., & Aron-Dine, S. (**2024**). Re-measuring gentrification.

Theories of Gentrification

- **Several** economic and social **theories**.
  1. Economic theories (rent gap)
  2. Social theories (demand-side)



[7]

- The **Rent Gap**:
  - "... between the actual capitalized **ground rent** of a plot of land given its **present** use and the **potential** ground rent that might be gleaned under a "**higher and better**" use"[6].

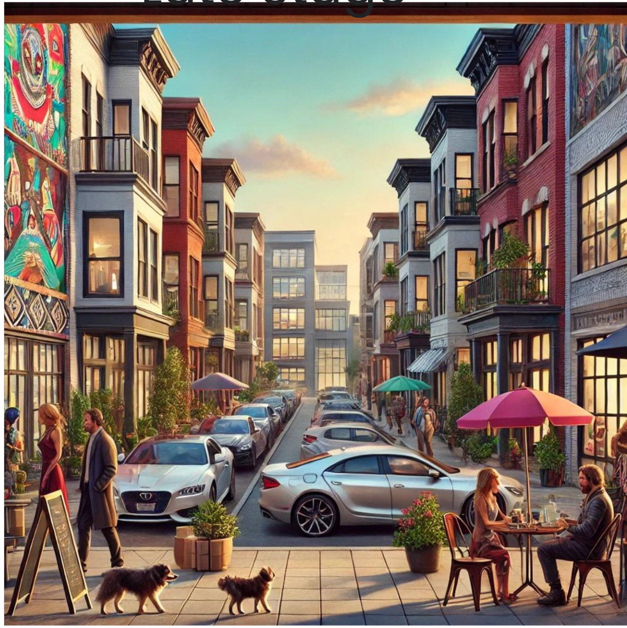
[6]Smith, N. (1987). Gentrification and the rent gap.
[7] Illustration of how a rent gap grows over time. By Daniel Herriges, based on a similar chart by Neil Smith in " Toward a Theory of Gentrification A Back to the City Movement by Capital, not People", 1979

Theories of Gentrification Drivers

Early Stage

Transitional Stage

Late Stage



Inspired by

Caulfield, J., & Peake, L. (Eds.). (1996). *City Lives and City Forms: Critical Research and Canadian Urbanism*. University of Toronto Press.

Ley, D. (2003). Artists, aestheticisation and the field of gentrification. *Urban studies*, *40*(12), 2527-2544.

Images: DALL-E

How to model Gentrification?

Rent Gap

- Deriving theoretical equations [8]
- Transactions of owners-buyers [9]

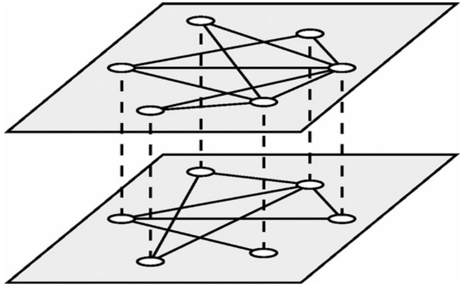
[8] Redfern, P. A. (1997). A new look at gentrification: 2. A model of gentrification.
[9] O'Sullivan, D. (2002). Toward micro-scale spatial modeling of gentrification.

Demand Side

- As a contagious process [11]
- Theory and data informed model [12]

[11] Liu, C., & O'Sullivan, D. (2016). An abstract model of gentrification as a spatially contagious succession process.
[12] Torrens, P. M., & Nara, A. (2007). Modeling gentrification dynamics: A hybrid approach.

How to model Gentrification?

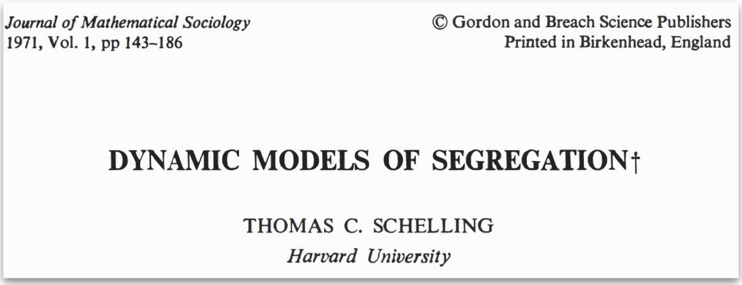


Gomez, S.,et al. Diffusion dynamics on multiplex networks.

1. Low-parameter (ABM) simulation

2.Based on **people** choices and **economic** conditions

3.Output: temporal **multilayer** network of relocations



Journal of Mathematical Sociology
1971, Vol. 1, pp 143–186

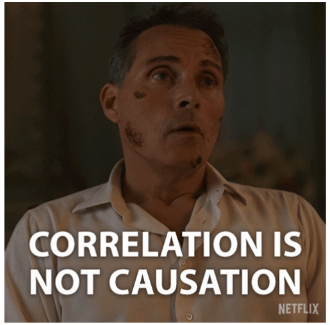
© Gordon and Breach Science Publishers
Printed in Birkenhead, England

DYNAMIC MODELS OF SEGREGATION†

THOMAS C. SCHELLING
Harvard University

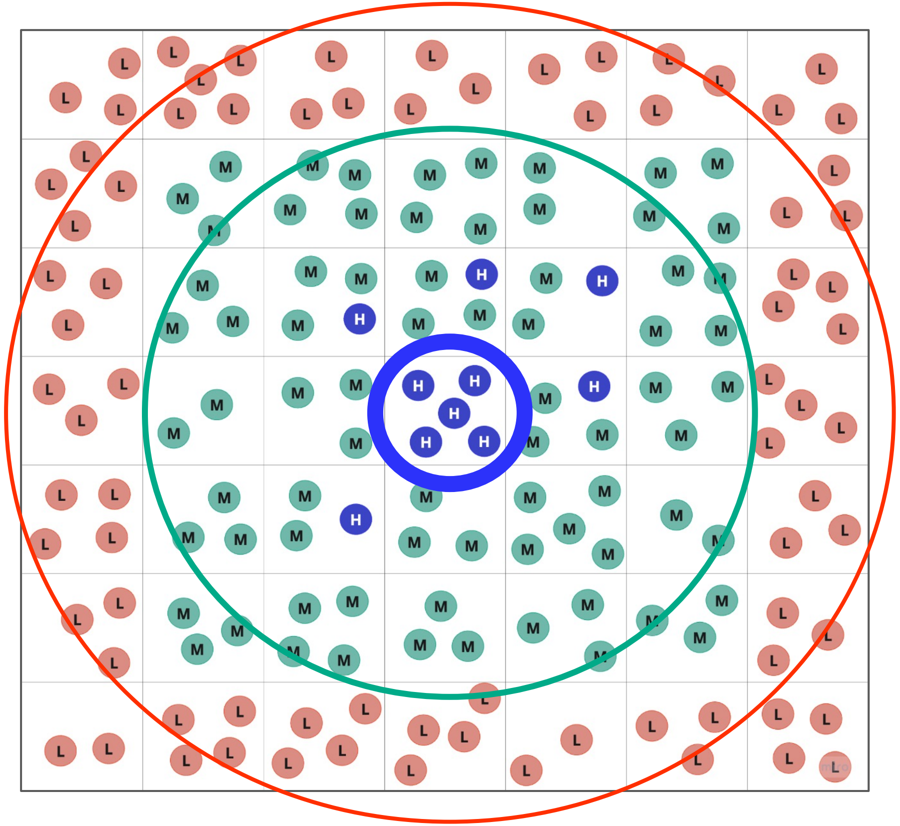
KISS

Keep. It. Simple. Stupid.



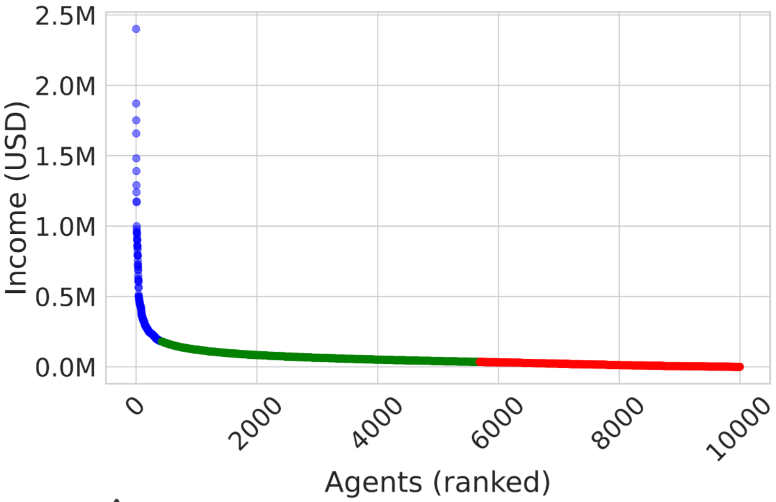
Initialization

- City as a **lattice**
- **3** types of agents:
    1. Low income
    2. Middle income
    3. High income
- Each cell starts ~75% full



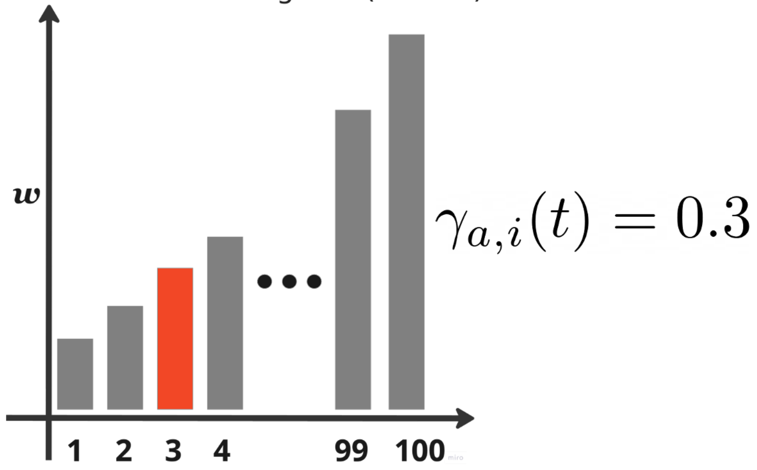
Income and class

- The **fixed income** *w* of an agent *a* is **sampled** from US 2022 Social Security Administration data [13]



- The income **percentile** of an agent *a* in node *i* at time *t* is indicated as

$$\gamma_{a,i}(t)$$



[13] Mantzaris, A. V. (2020). Incorporating a monetary variable into the Schelling model addresses the issue of a decreasing entropy trace.

Segregation.png

maxwatsongeography.wordpress.com

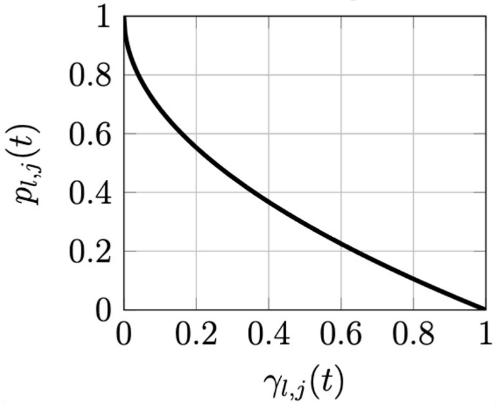
Gentrification.avi

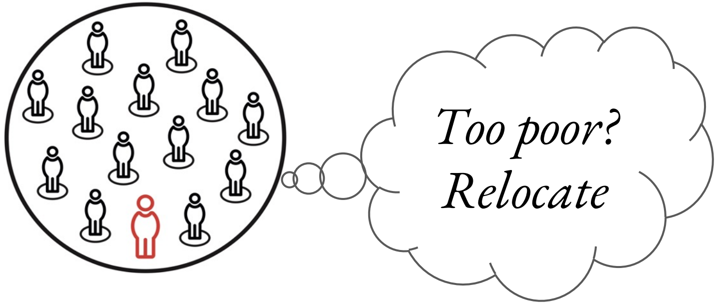
artfcity.com

1) Low income agent *l*:

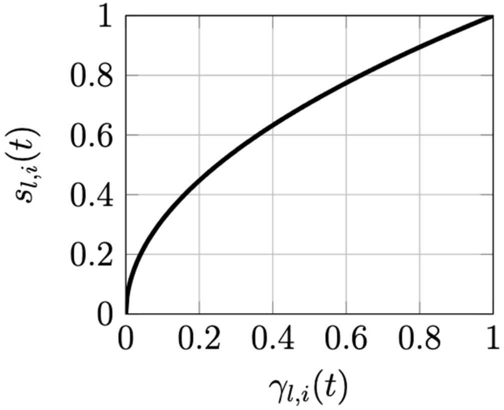
~38%

Evaluation phase





Movement phase

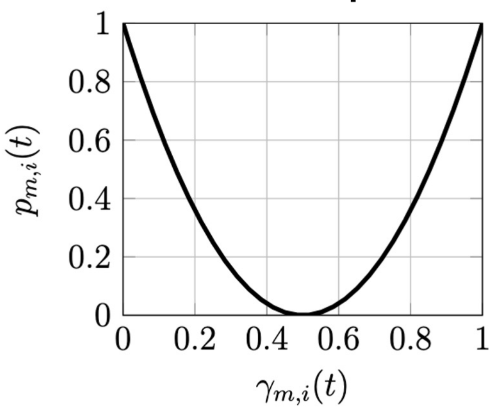


gamcare.com

2) Middle income agent *m*:

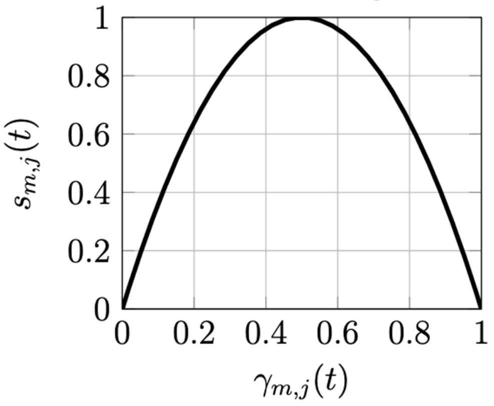
~57%

Evaluation phase



I want to stay middle!

Movement phase



I said I want to stay middle.

3) High income agent *h*:

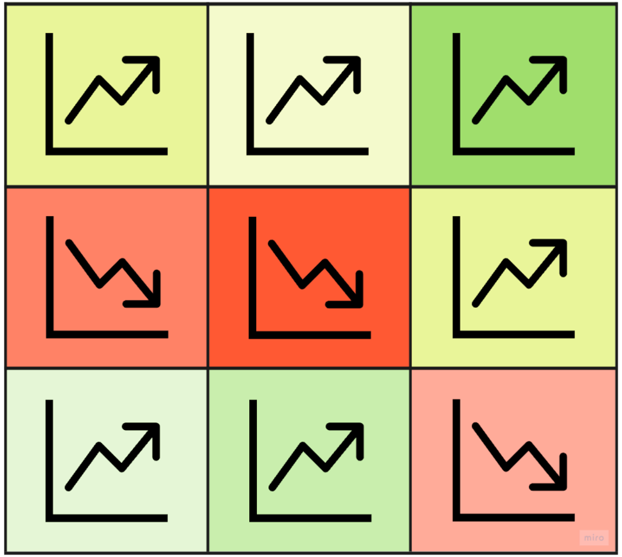
~5%

Evaluation phase

$$p_h$$

Movement phase

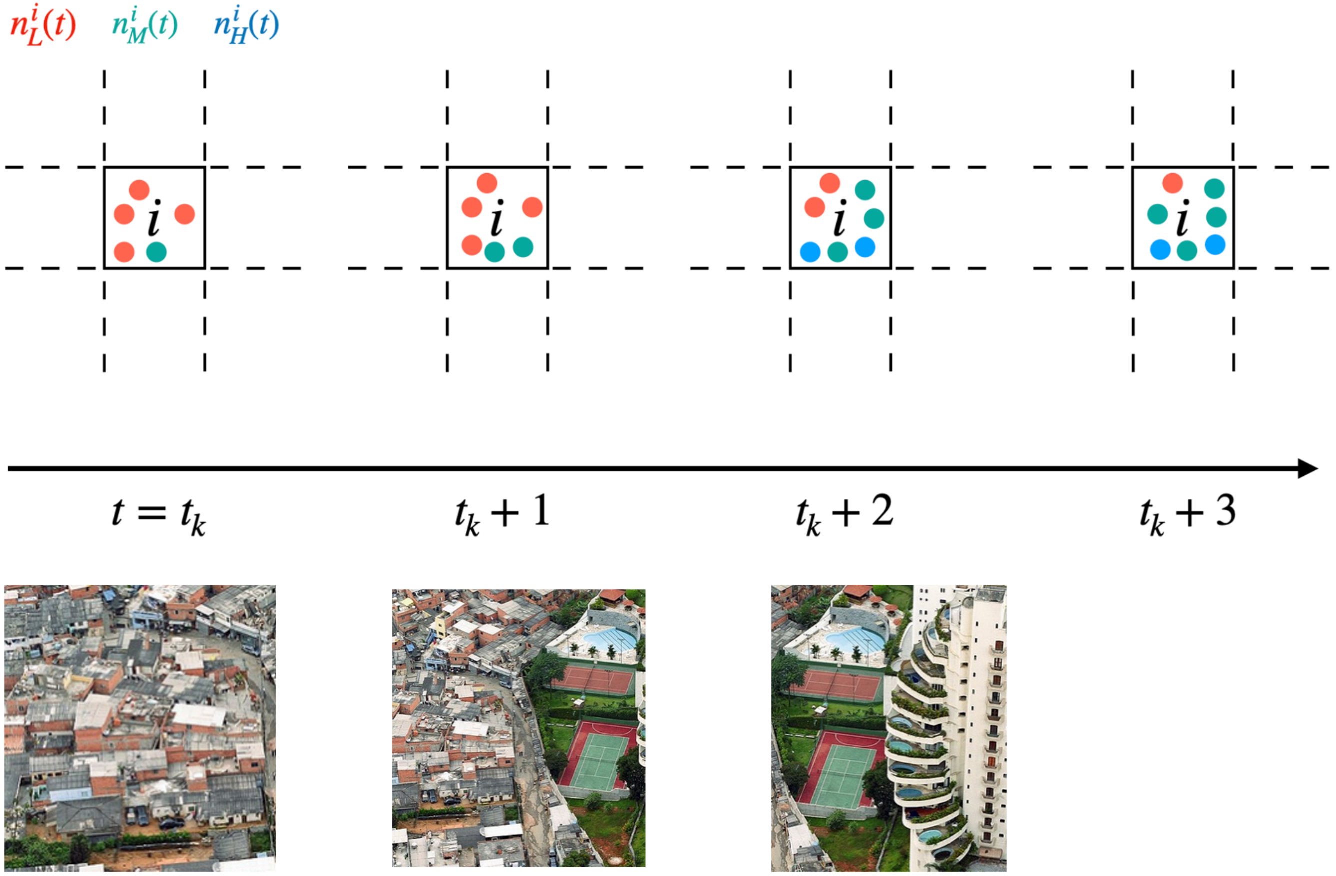
ε



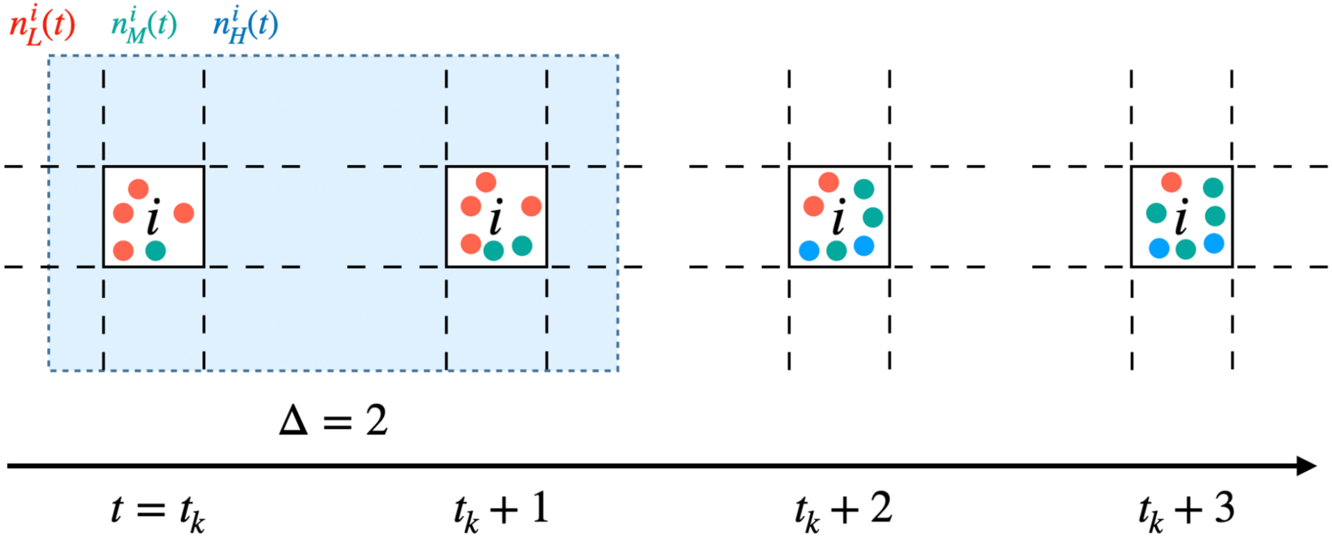
$$p(x) \propto \mathrm{trend}_\epsilon(x)$$

MEASURING GENTRIFICATION

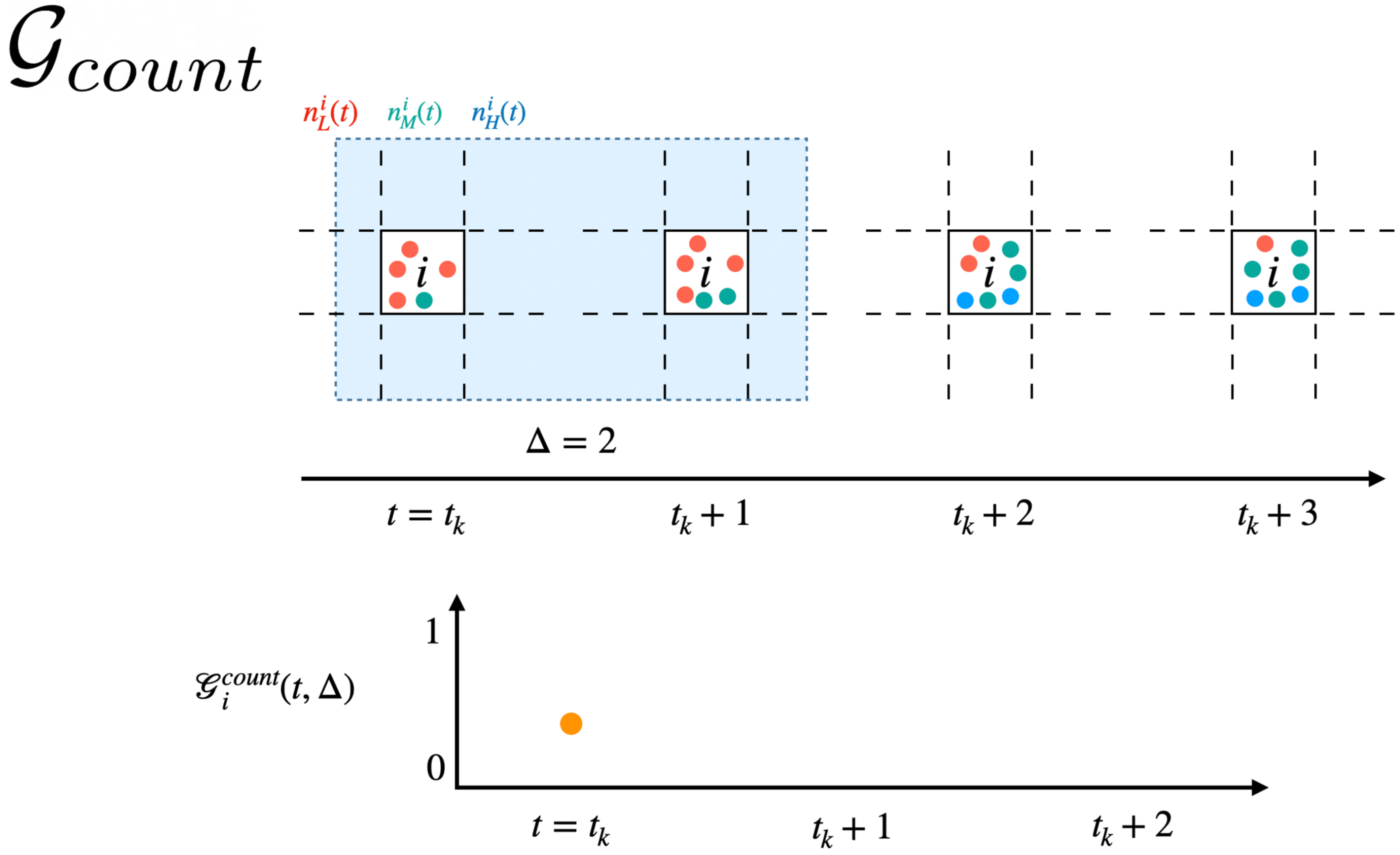
$\mathcal{G}_{count}$



$\mathcal{G}_{count}$

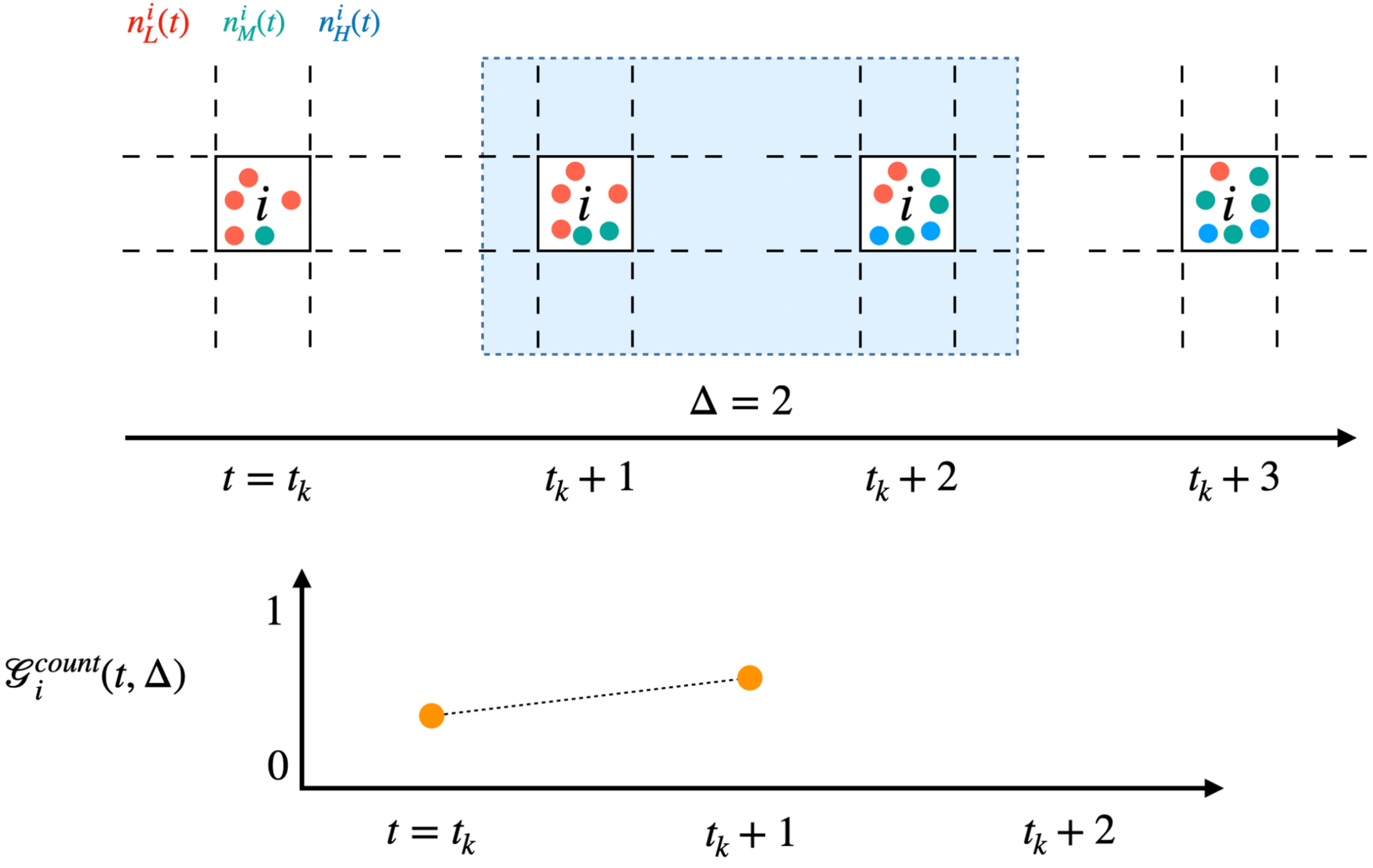


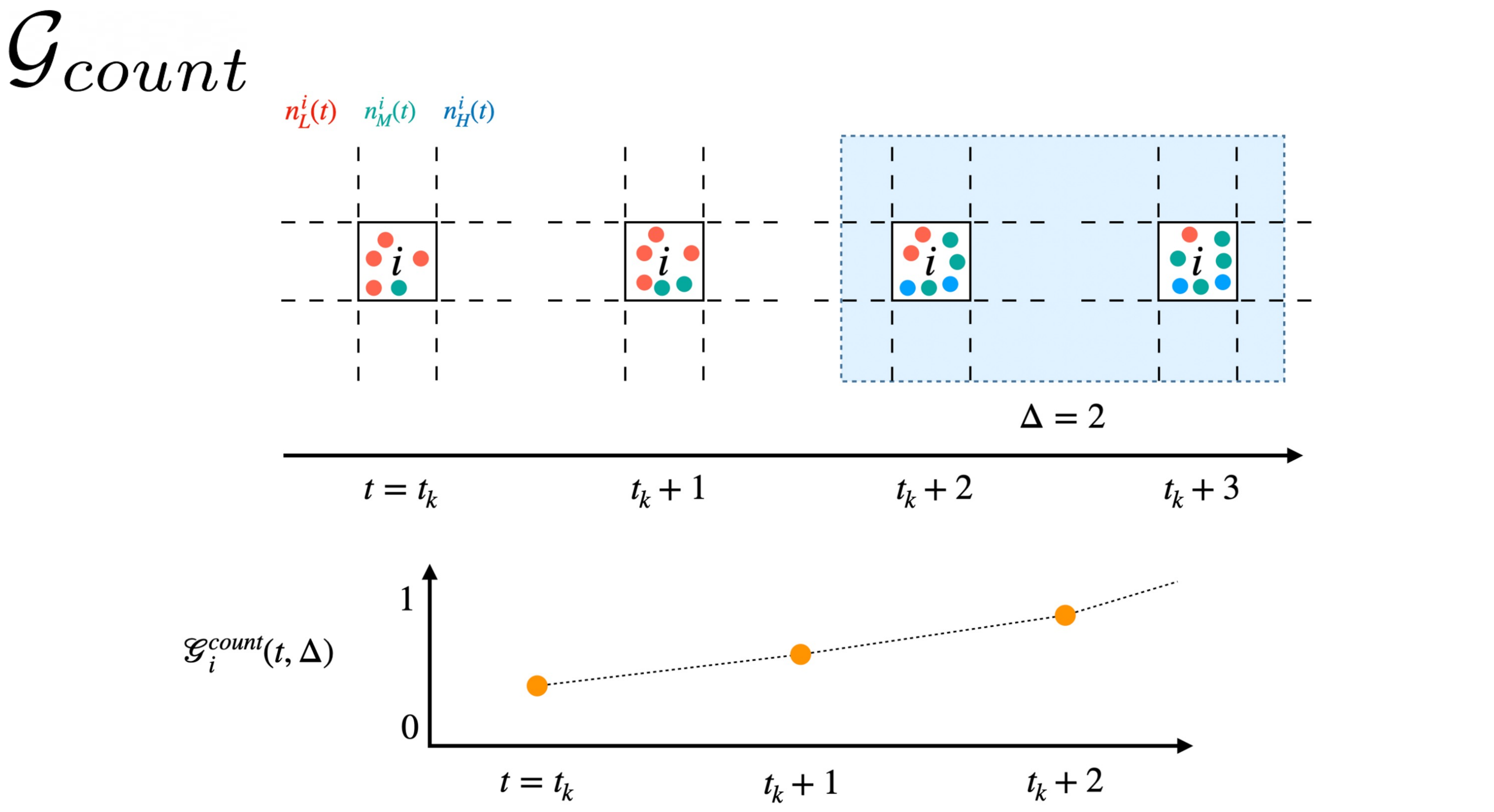
$$\mathcal{G}_i^{count}(t, \Delta) = \frac{1}{\Delta} \sum_{\tau=t}^{t+\Delta} \frac{n_H^i(\tau) + n_M^i(\tau)}{n_H^i(\tau) + n_M^i(\tau) + n_L^i(\tau)}$$



$\mathcal{G}_{count}$
$n_L^i(t)$ $n_M^i(t)$ $n_H^i(t)$
i
$\Delta = 2$
$t = t_k$
$t_k + 1$
$t_k + 2$
$t_k + 3$
$\mathcal{G}_i^{count}(t, \Delta)$
1
0
$t = t_k$
$t_k + 1$
$t_k + 2$

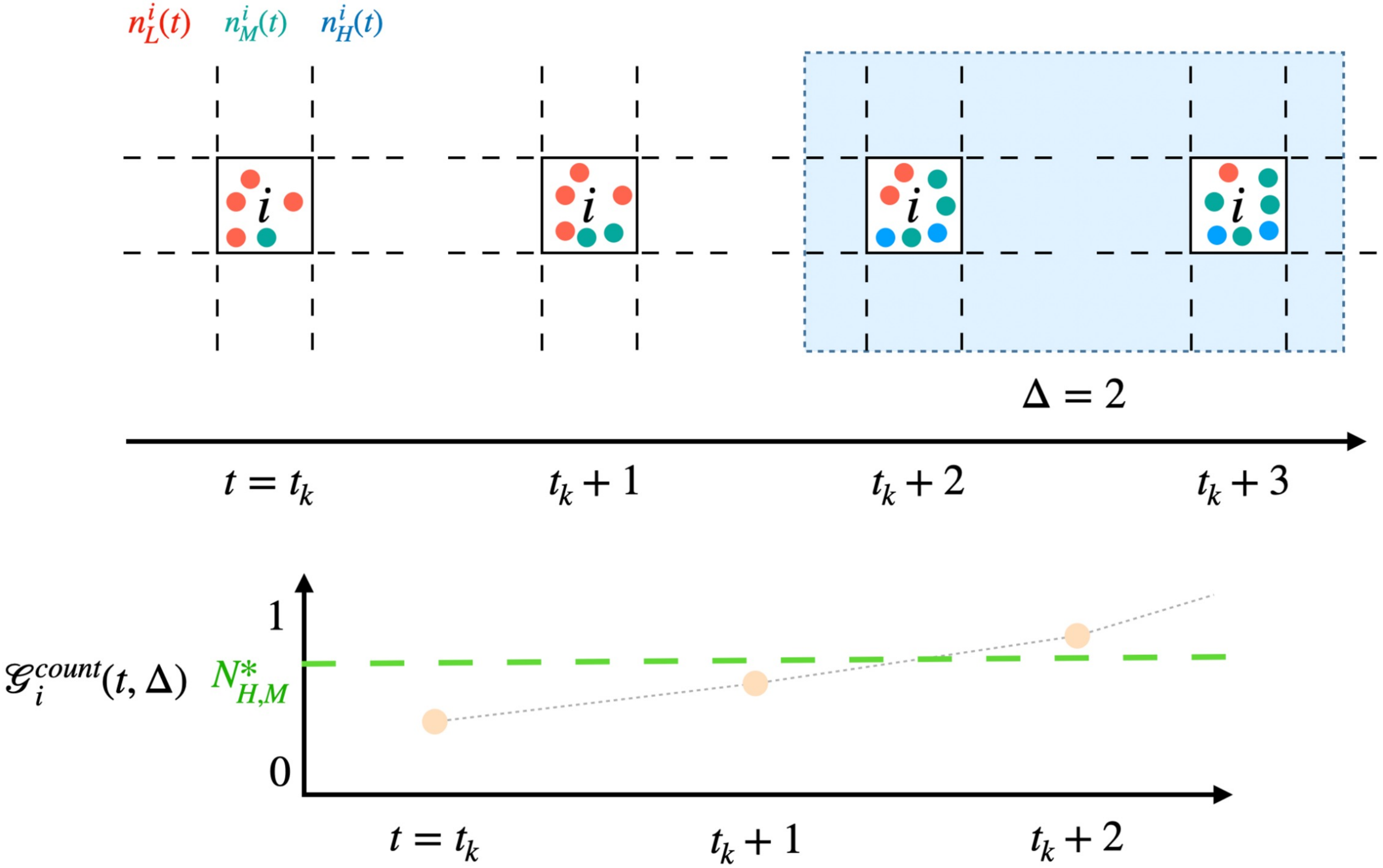
$\mathcal{G}_{count}$



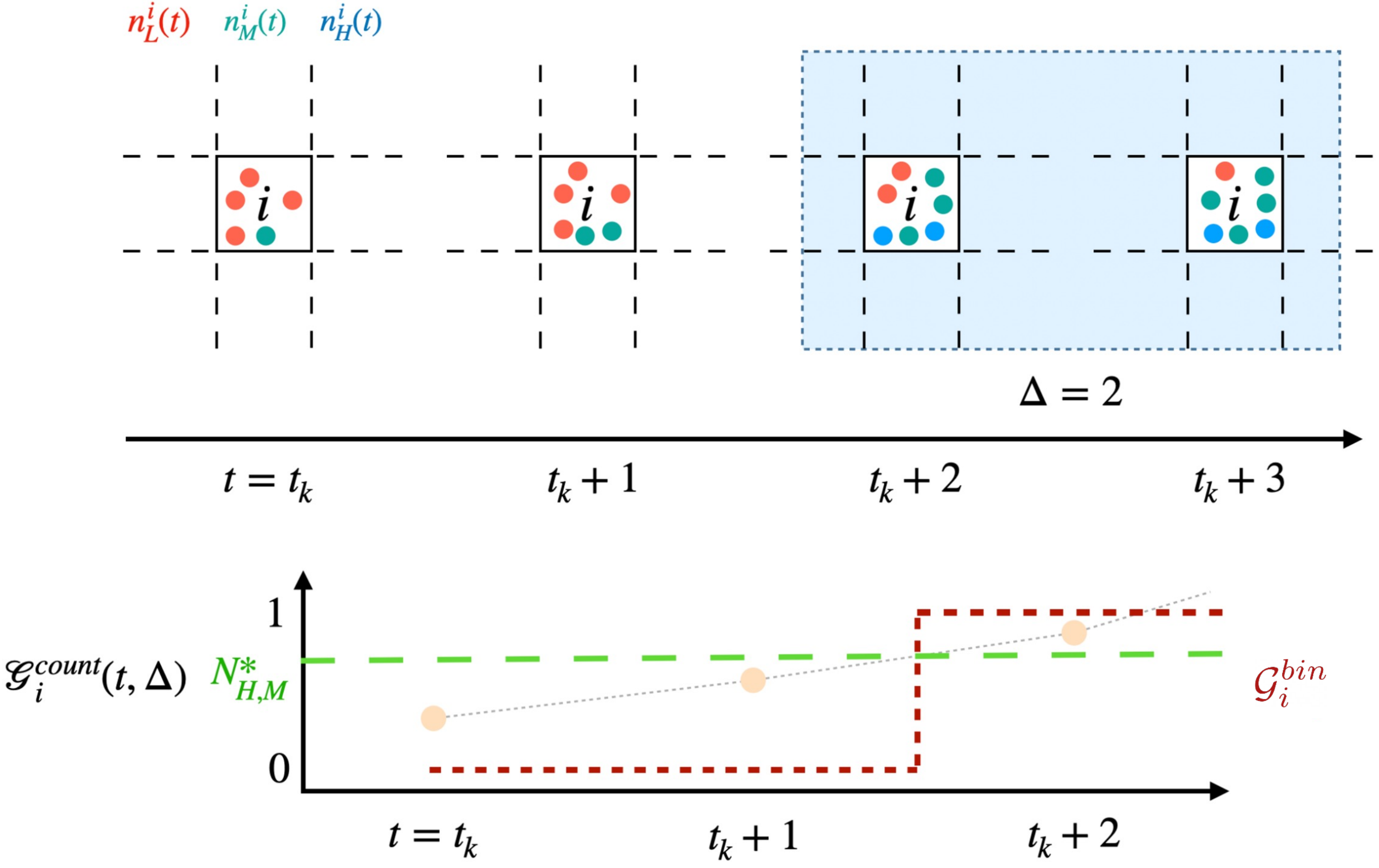


$\mathcal{G}_{count}$
$n_L^i(t)$
$n_M^i(t)$
$n_H^i(t)$
i
$\Delta = 2$
$t = t_k$
$t_k + 1$
$t_k + 2$
$t_k + 3$
$\mathcal{G}_i^{count}(t, \Delta)$
1
0
$t = t_k$
$t_k + 1$
$t_k + 2$

$\mathcal{G}_{count}$

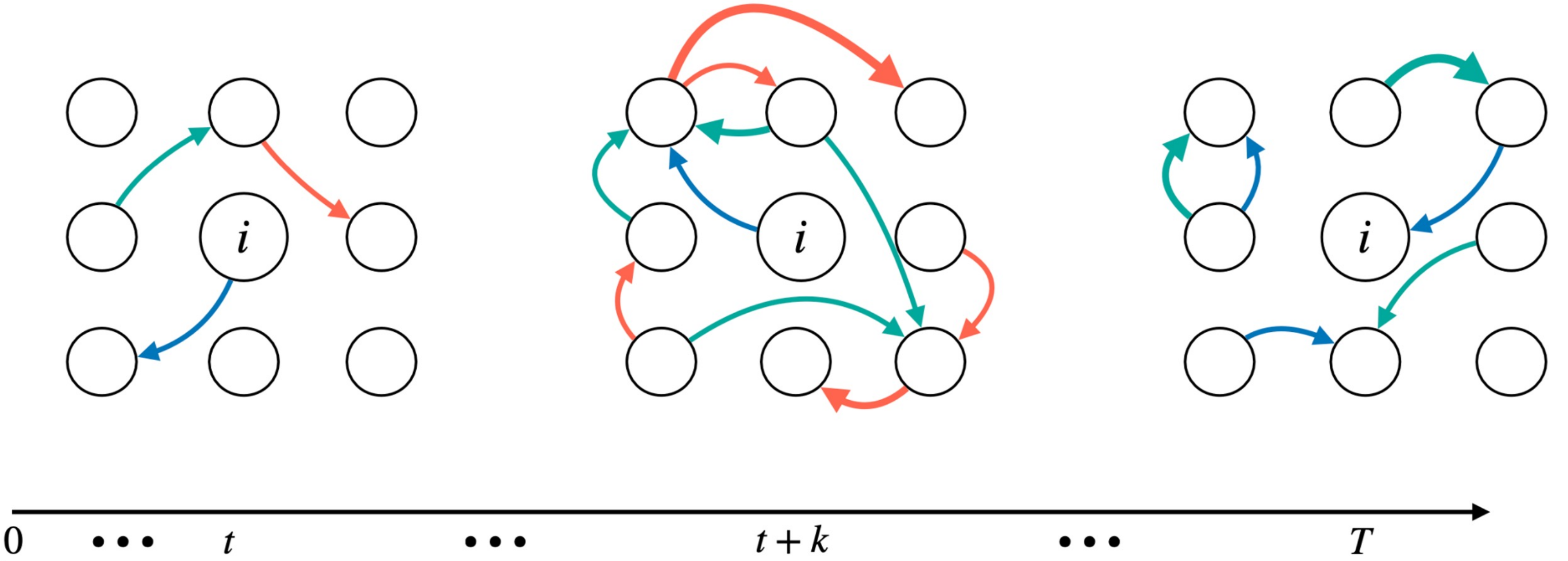


$\mathcal{G}_{count}$

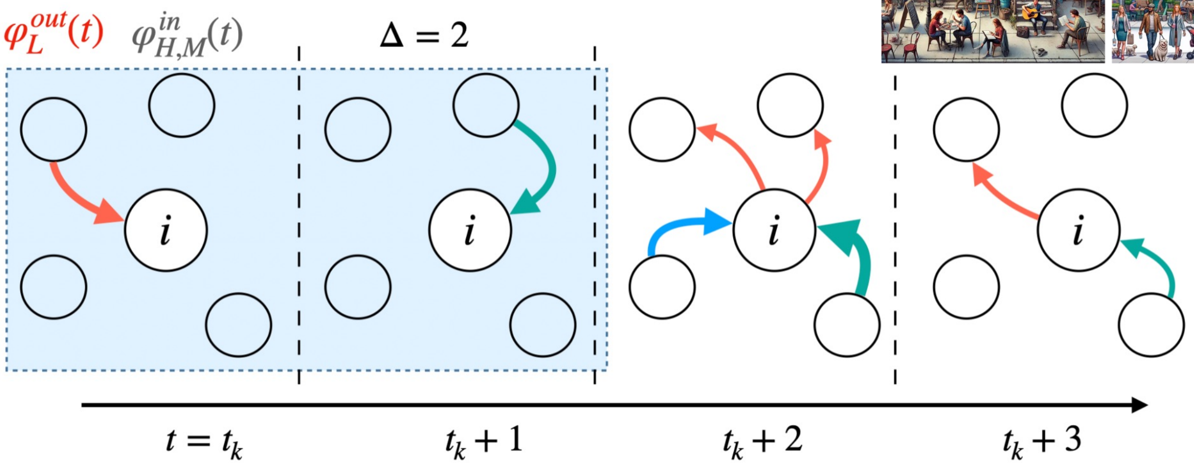


Where's the network?

- **Temporal**, Multilayer network of flows
- **Nodes**: neighborhoods
- **Edges**: #agents moving at time *t*



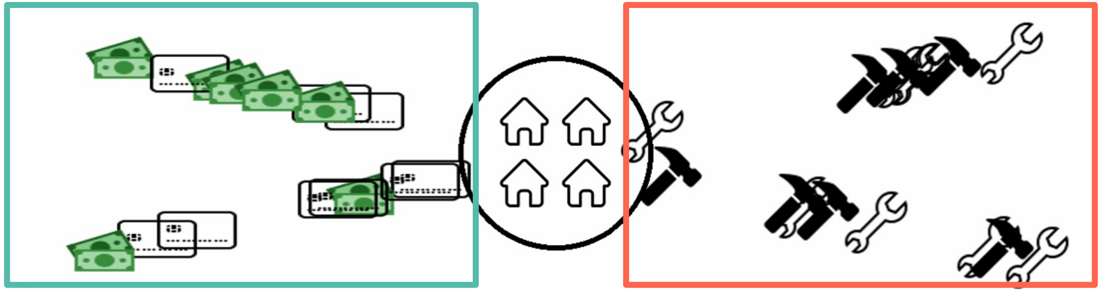
$\mathcal{G}_{net}$



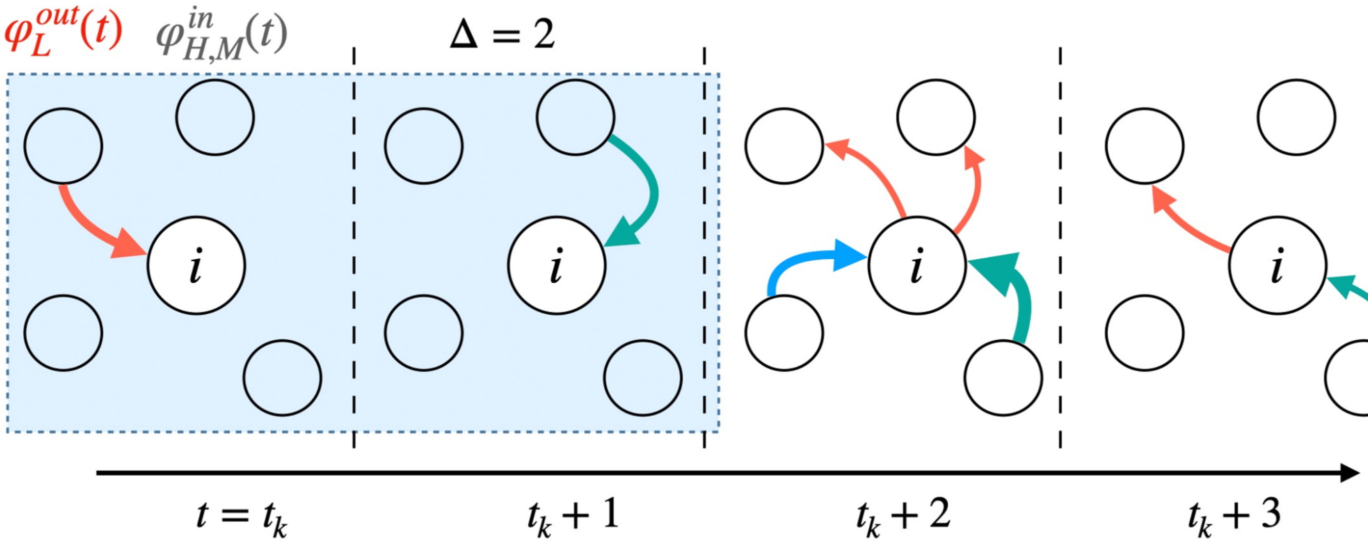
$$\mathcal{G}_i^{net}(t, \Delta) \equiv \left(\frac{1}{\Delta} \sum_{\tau=t-\Delta}^{t} \varphi_i^{out}(\tau) \right) \cdot \left(\frac{1}{\Delta} \sum_{\tau=t-\Delta}^{t} \varphi_i^{in}(\tau) \right)$$

$\mathcal{G}_{net}$

$$\mathcal{G}_i^{\text{net}}(t,\Delta) \equiv \boxed{\left(\frac{1}{\Delta}\sum_{\tau=t-\Delta}^{t}\varphi_i^{\text{in}}(\tau)\right)} \cdot \boxed{\left(\frac{1}{\Delta}\sum_{\tau=t-\Delta}^{t}\varphi_i^{\text{out}}(\tau)\right)}$$

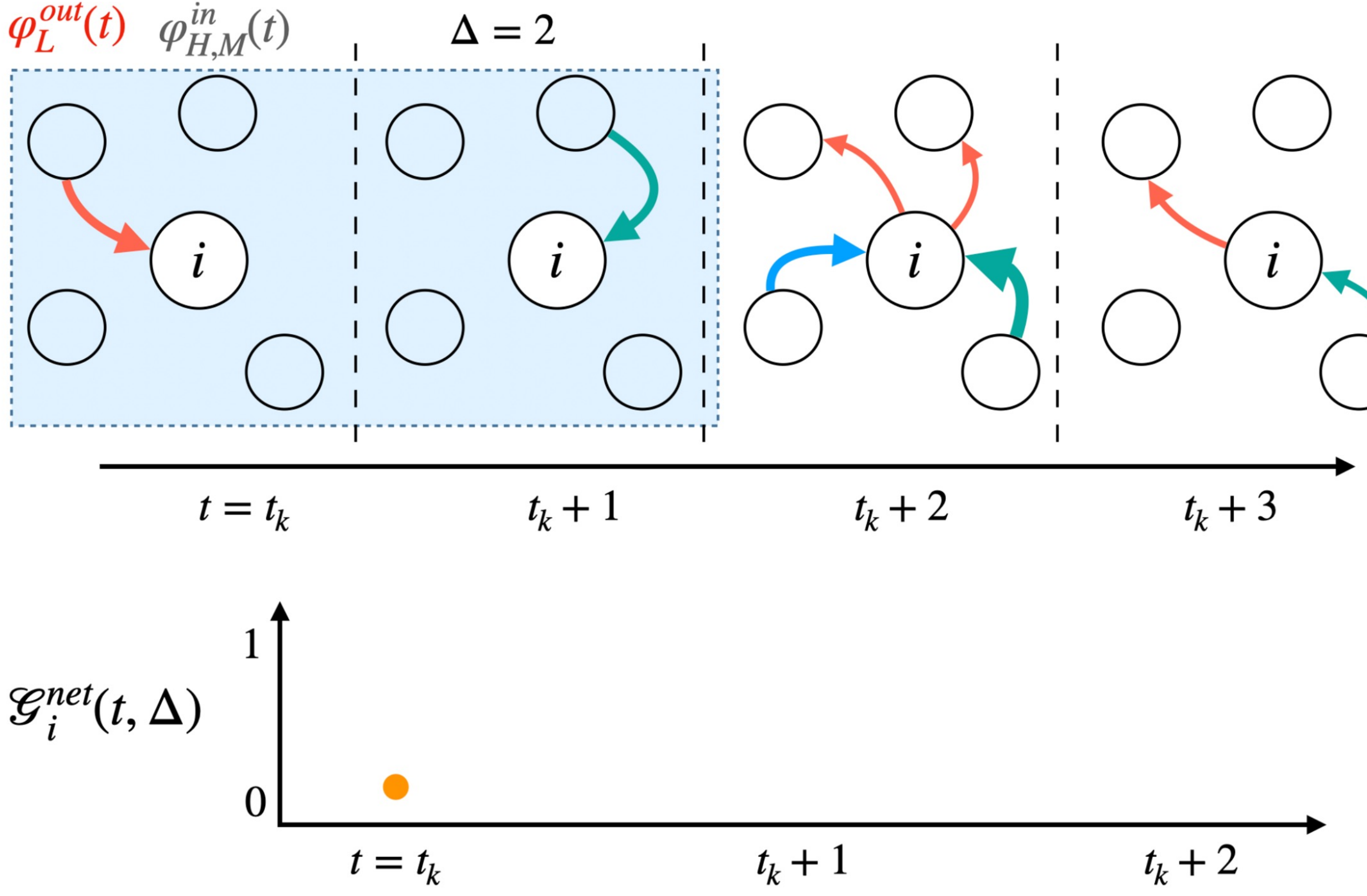


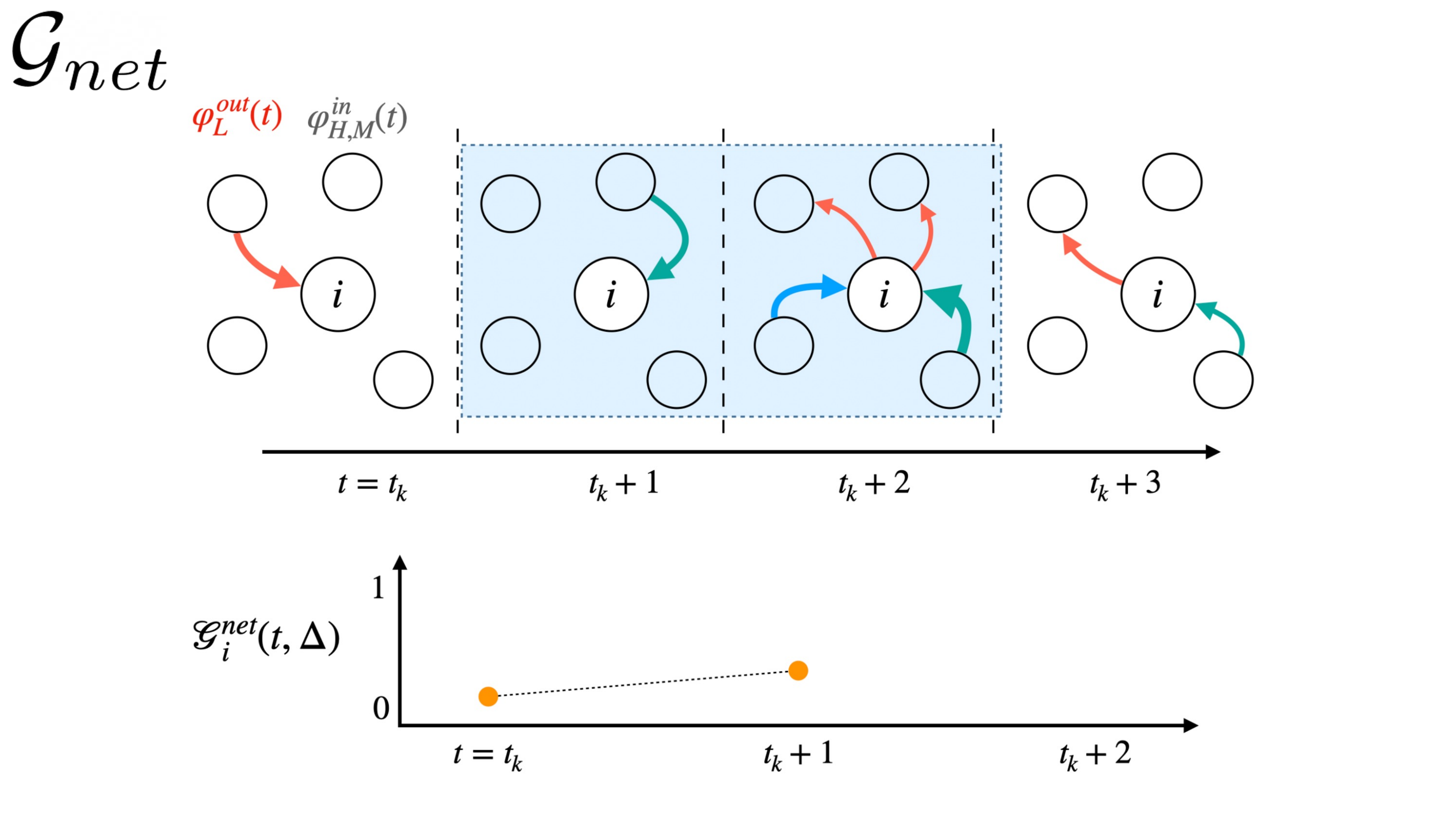
$\mathcal{G}_{net}$



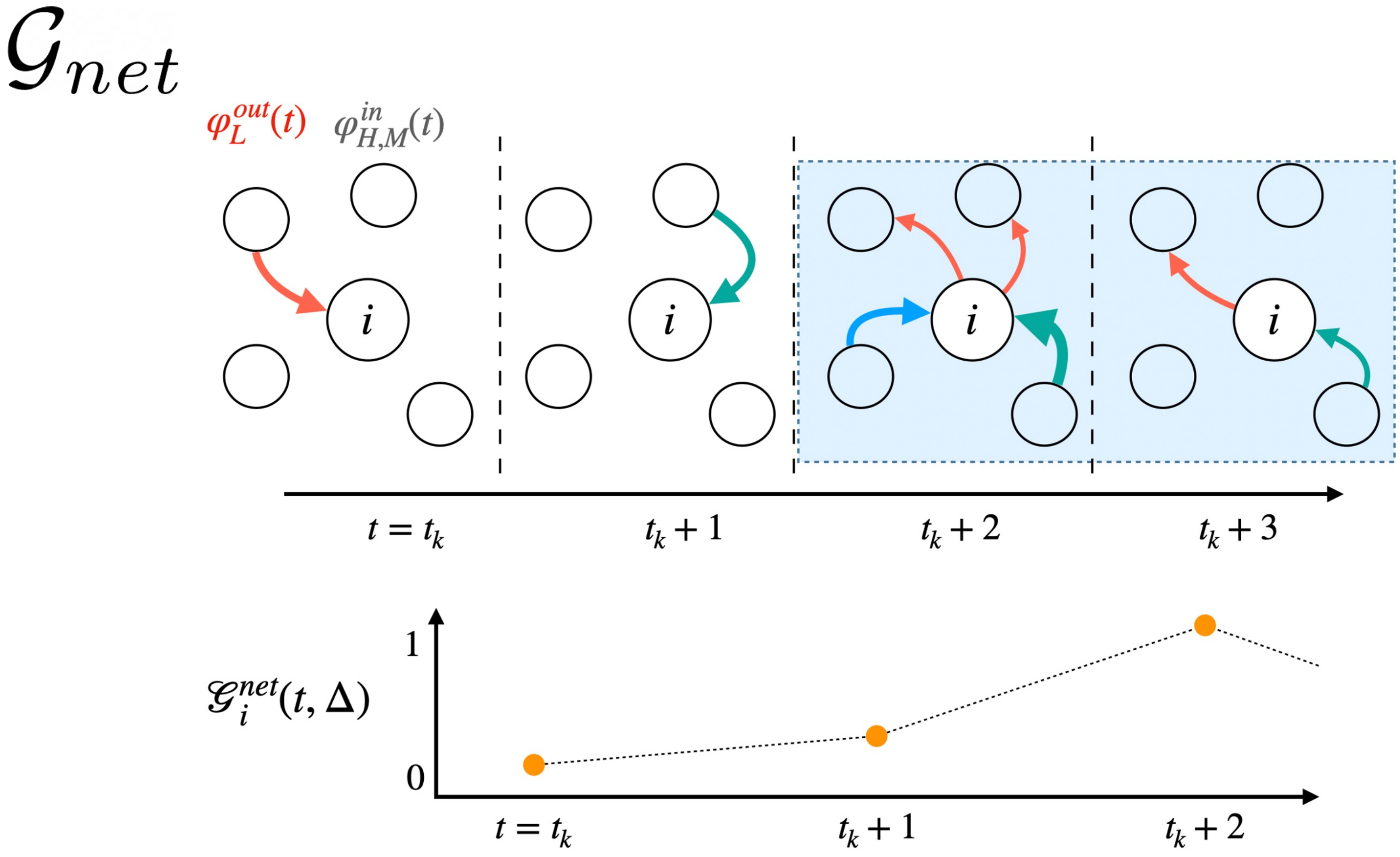
$$\mathcal{G}_i^{net}(t, \Delta) \equiv \sqrt{\left(\frac{1}{\Delta}\sum_{\tau=t-\Delta}^{t} \varphi_i^{out}(\tau)\right) \cdot \left(\frac{1}{\Delta}\sum_{\tau=t-\Delta}^{t} \varphi_i^{in}(\tau)\right)}$$

$\mathcal{G}_{net}$

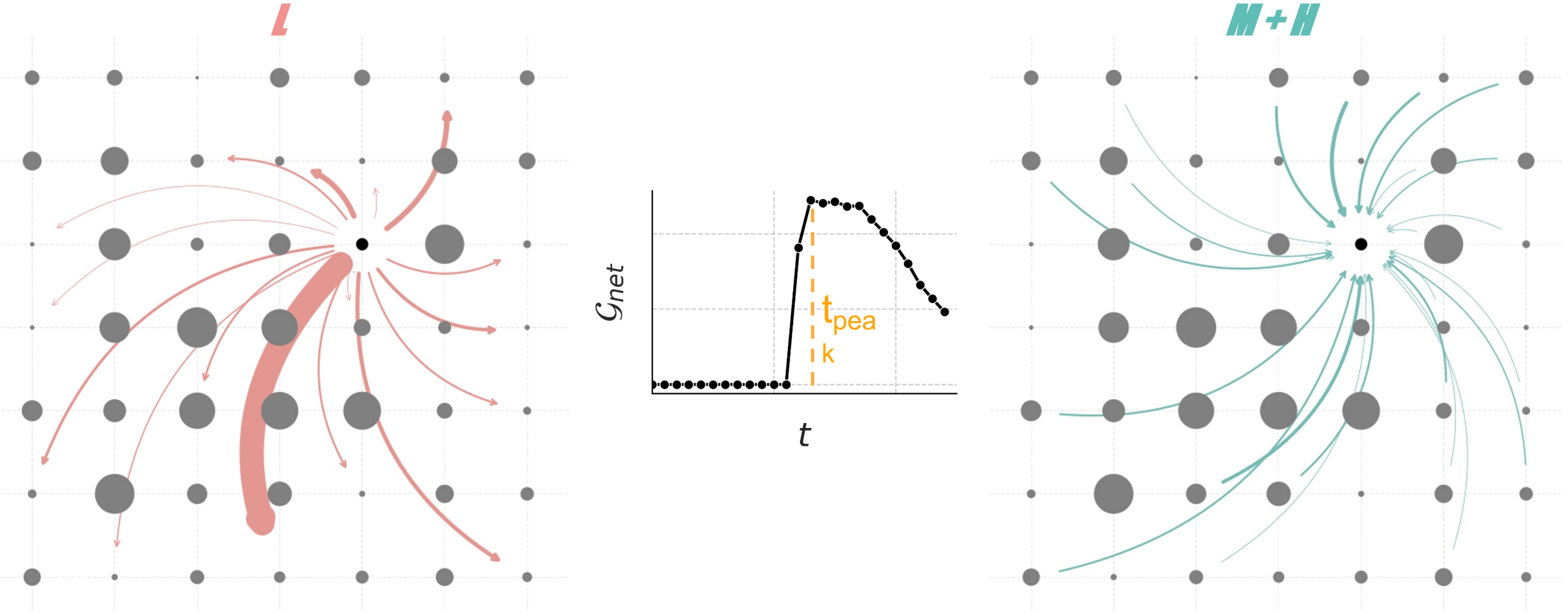


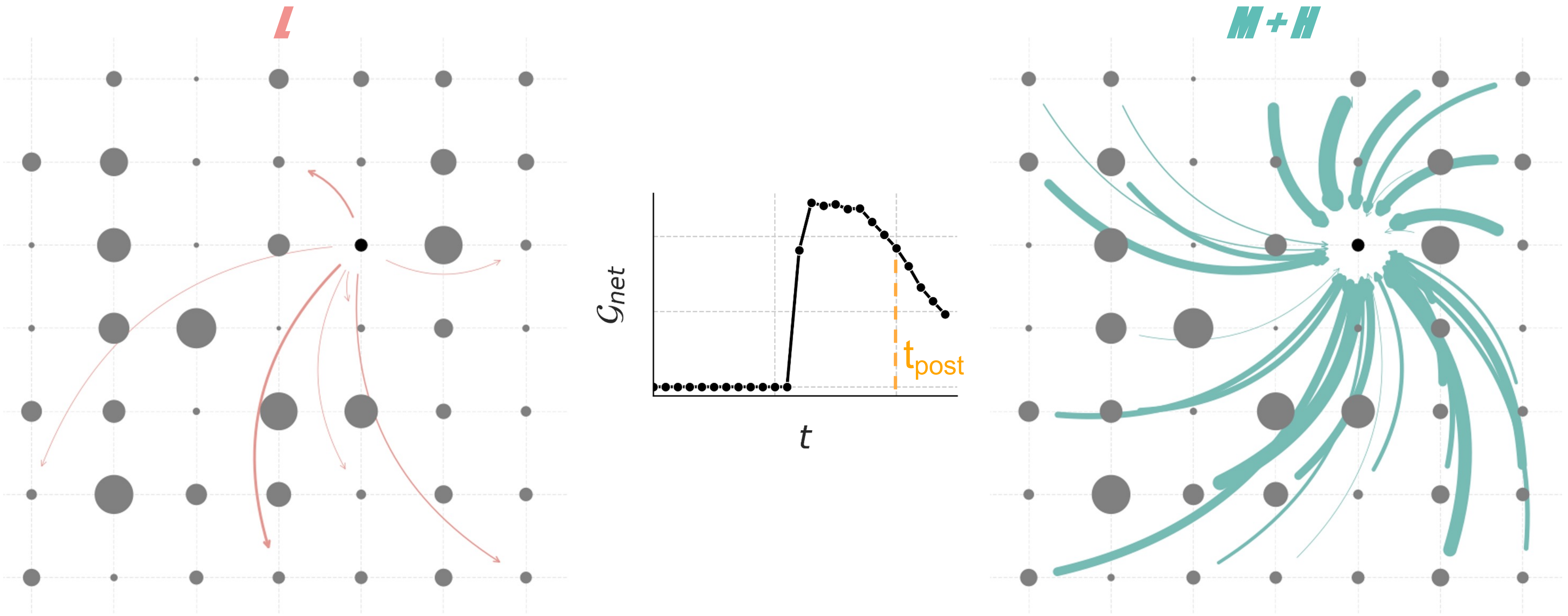


$\mathcal{G}_{net}$
$\varphi_L^{out}(t)$
$\varphi_{H,M}^{in}(t)$
i
$t = t_k$
$t_k + 1$
$t_k + 2$
$t_k + 3$
$\mathscr{G}_i^{net}(t, \Delta)$
1
0
$t = t_k$
$t_k + 1$
$t_k + 2$



$\mathcal{G}_{net}$
$\varphi_L^{out}(t)$
$\varphi_{H,M}^{in}(t)$
i
$t = t_k$
$t_k + 1$
$t_k + 2$
$t_k + 3$
$\mathcal{G}_i^{net}(t, \Delta)$
1
0
$t = t_k$
$t_k + 1$
$t_k + 2$

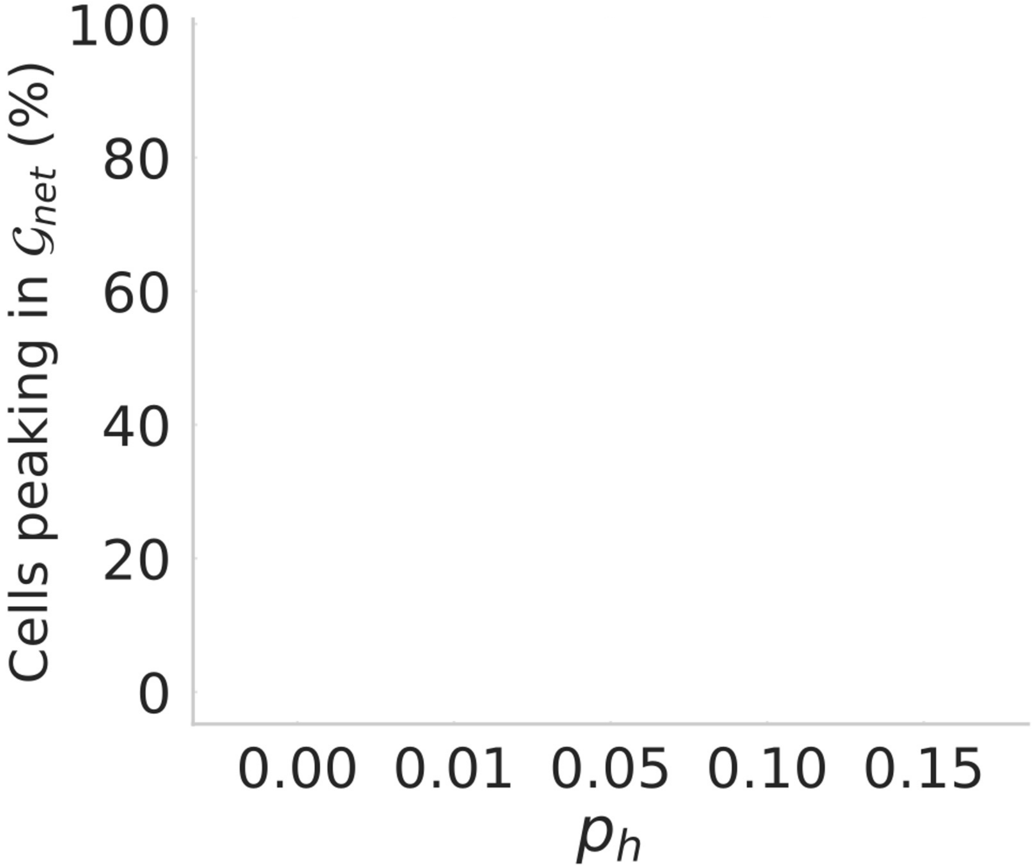

L
M+H
$\mathcal{G}_{net}$
t
t_{peak}



L
$\mathcal{G}_{net}$
t_{post}
t
M+H

Results I

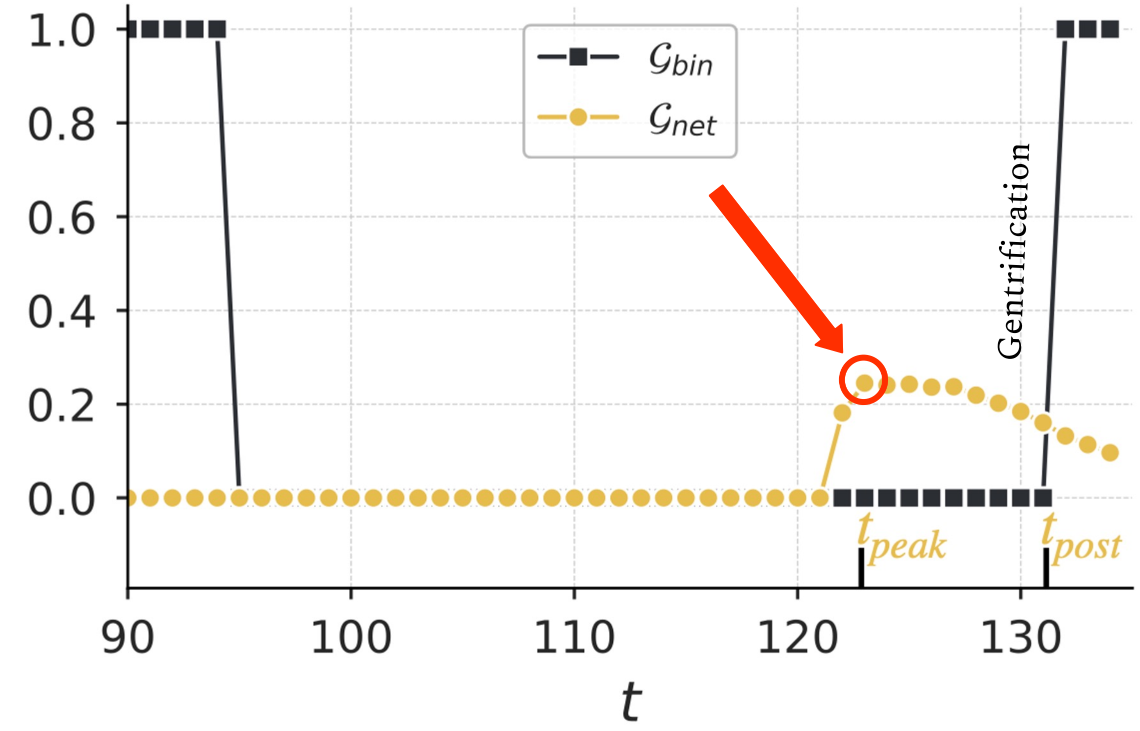
No rich = No gentrification



150 rep x box

Results II

$\mathcal{G}_{net}$ is an early-warning of $\mathcal{G}_{bin}$



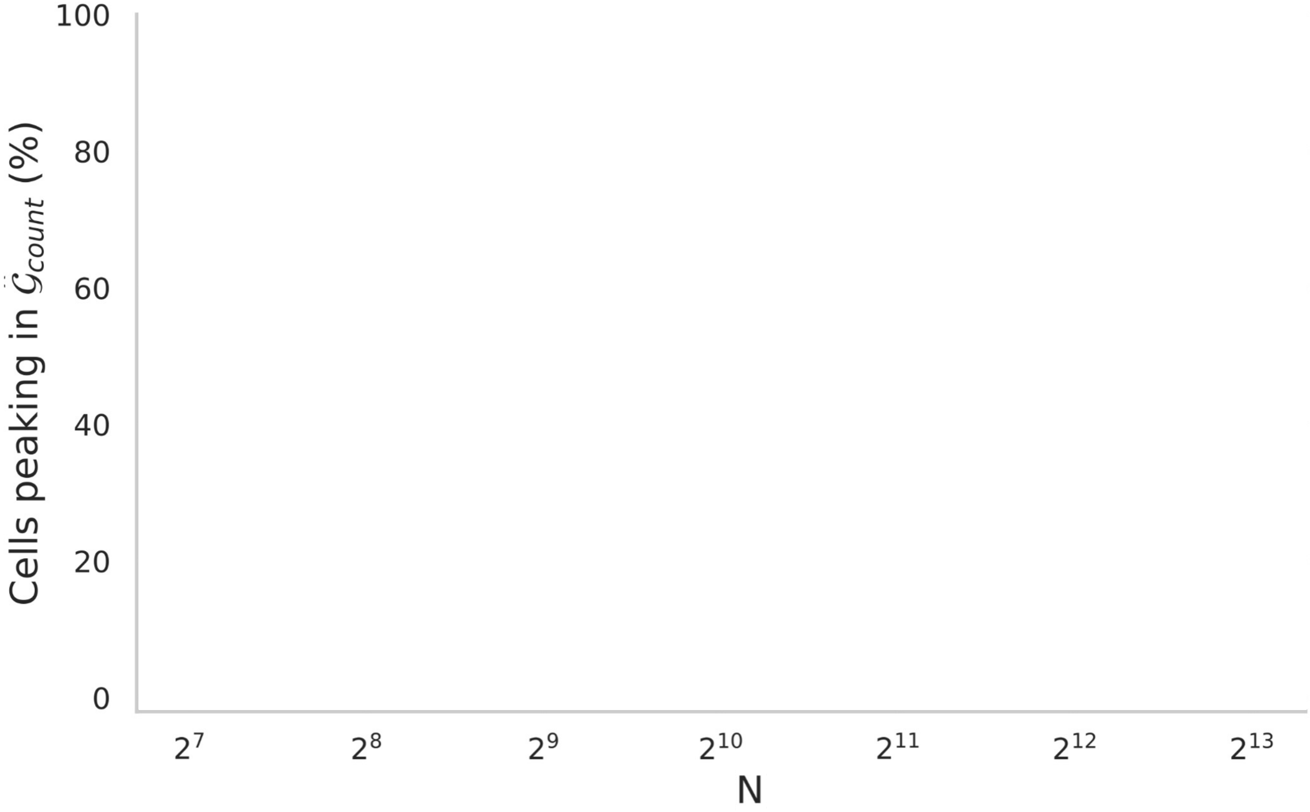
❌ Threshold
❌ Abrupt change

✅ Threshold
✅ Abrupt change

Coordinated flows peak before population "proportions"

Results III

Denser cities = Higher Gentrification



Results

1. Super **High**-Income citizen are the drivers
   1. **Middle**-Income citizen are the triggers
   2. **Low**-income citizen are the displaced
2. **Coordinated flows** reveals **early-warning** signals of Gentrification
   1. Residential **mobility** is key
3. **Bigger** and **denser** cities experience more Gentrification

Limitations

1. **Simplistic** urban **form**
2. **Fixed** population, income bracket, and city size
3. Not considering important **factors**
    1. Housing **prices**, mortgages, city council **interventions** etc.
4. **High-Income** especially can have **more houses**

Ongoing works

1. **Validation** on relocation datasets
   1. Parameter **fitting**
   2. Measure **significance**
2. Correlation with Gentrification proxies
   1. **AirBnB**, Idealista, Yelp…
3. Redundant/Synergistic ***CAUSES*** of Gentrification

Dynamic models of Gentrification

Paper




Giovanni Mauro, Nicola Pedreschi, Luca Pappalardo, Renaud Lambiotte

Consiglio Nazionale delle Ricerche

UNIVERSITY OF OXFORD

UNIVERSITÀ DI PISA

KDD Lab

SCUOLA NORMALE SUPERIORE

UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO