Geometric Networks - Some Problems and Applications

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Brief Bio

- PhD- Dept. of ECE, Indian Institute of Science, Bengaluru.
  Probabilistic Forwarding of Coded Packets for Broadcasting over Networks
- Postdoc- INRIA Sophia Antipolis, France.
  Community detection algorithms for geometric graphs and hypergraphs
- Research interests
  - random graphs
  - percolation
  - clustering
  - etc...

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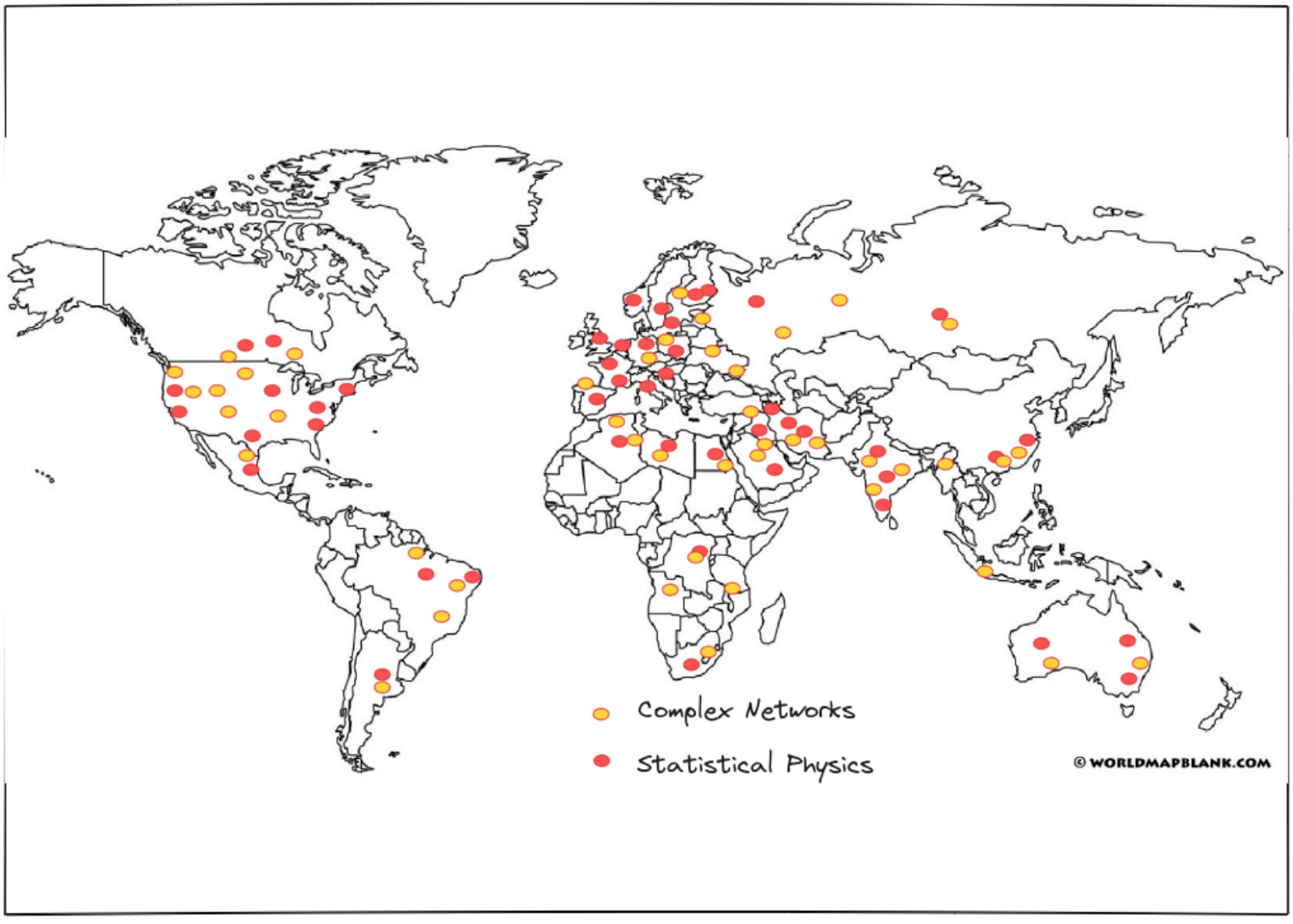
- **Mantra**: Capture observed physical phenomenon using robust mathematical models that can be analyzed

Community detection: co-authorship network



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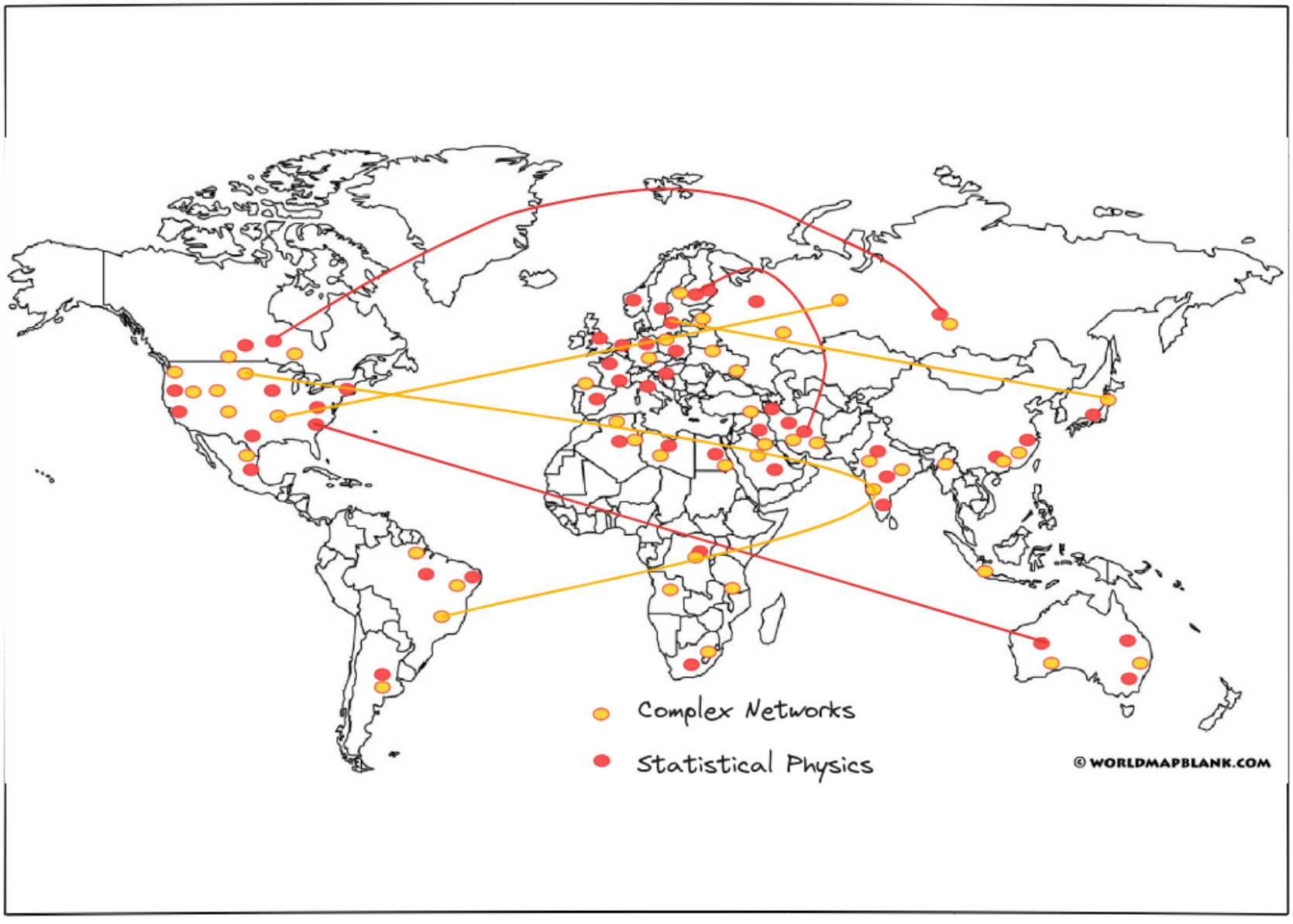

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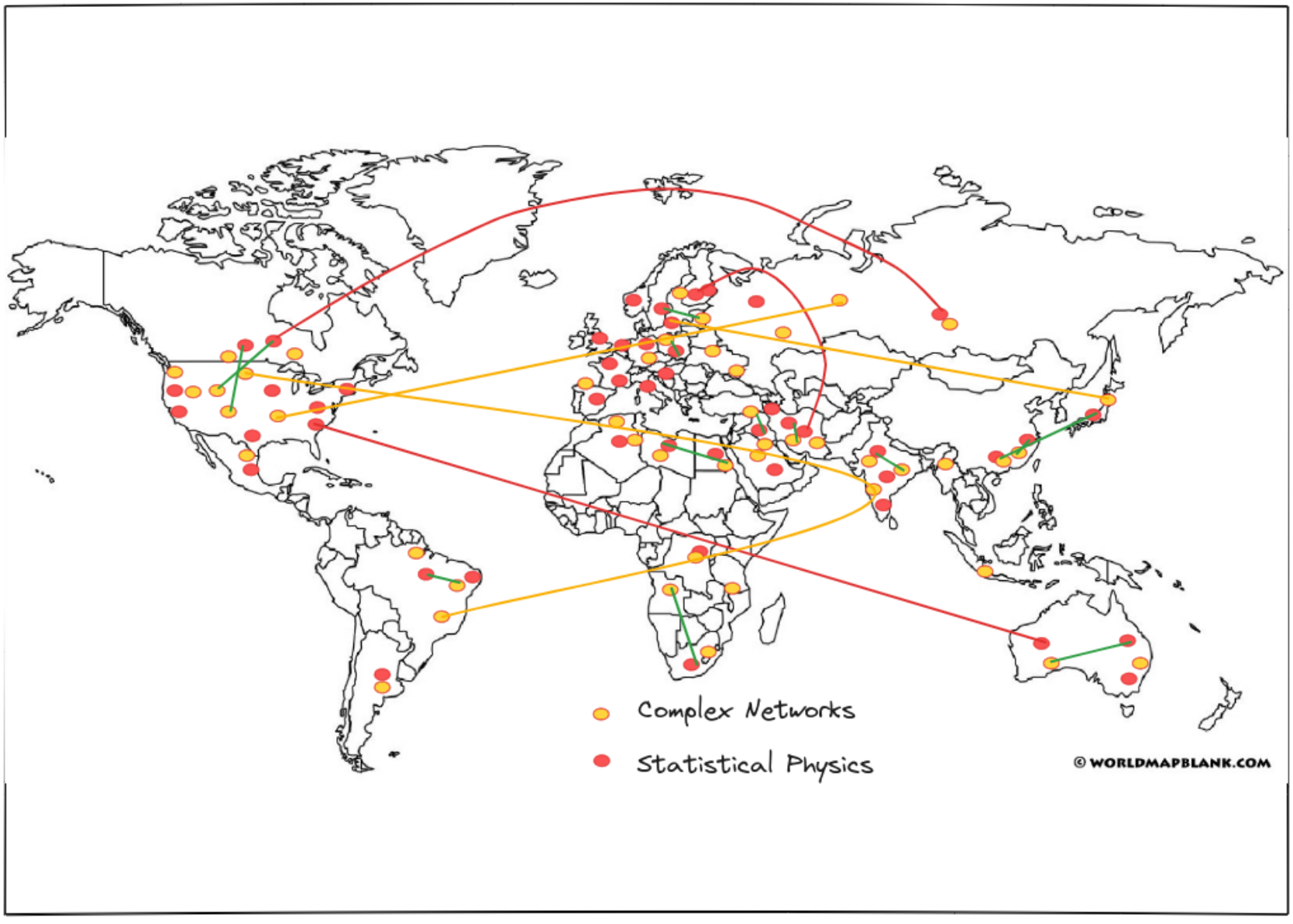
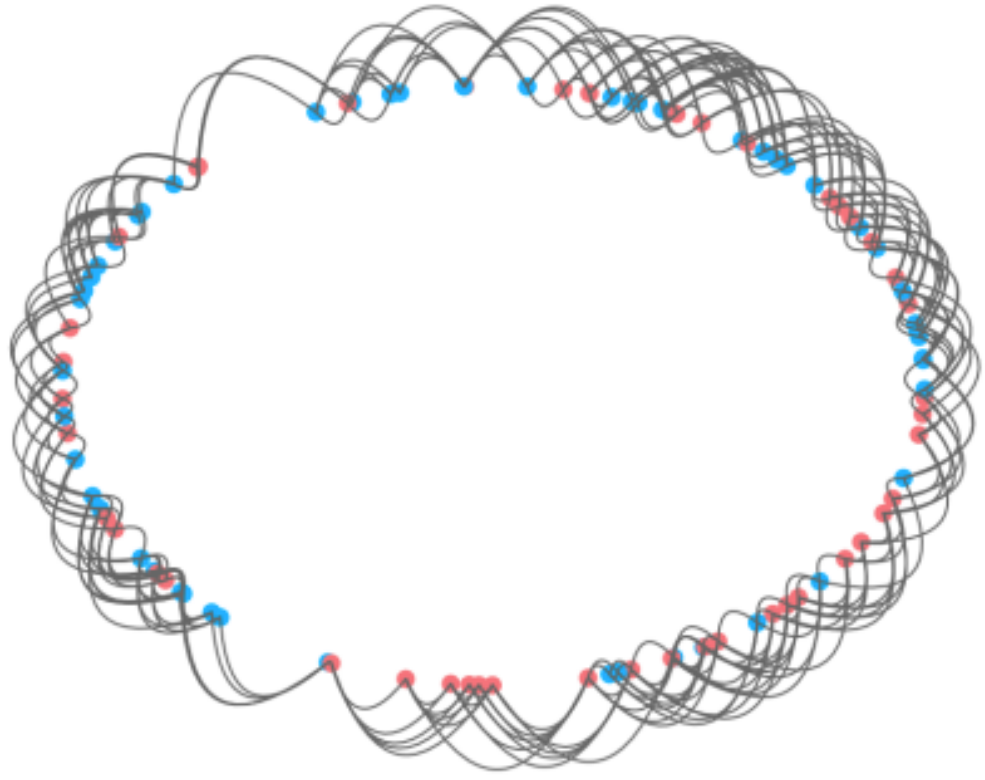


Geometric block model

- N nodes
- Two communities
  $\sigma_i \in \{-1, +1\}$
- Locations: $X_i \in [0,1]^d$
  uniformly
- Parameters: $a > b$
  For $d = 1$,

$$r_{in} = \frac{a \log N}{N}, r_{out} = \frac{b \log N}{N}$$



- Graph:

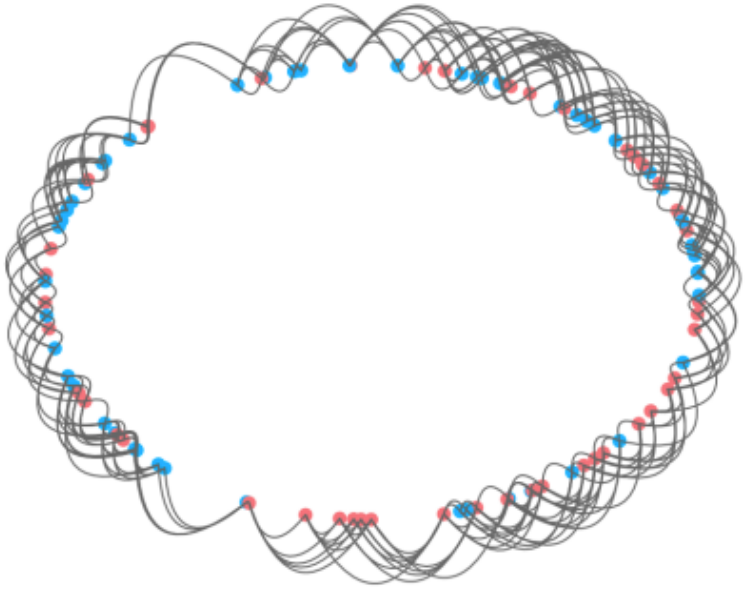
$$A_{ij} = 1 \begin{cases} \text{if } \sigma_i = \sigma_j \text{ and } ||X_i - X_j|| < r_{in} \\ \text{if } \sigma_i \neq \sigma_j \text{ and } ||X_i - X_j|| < r_{out} \end{cases}$$

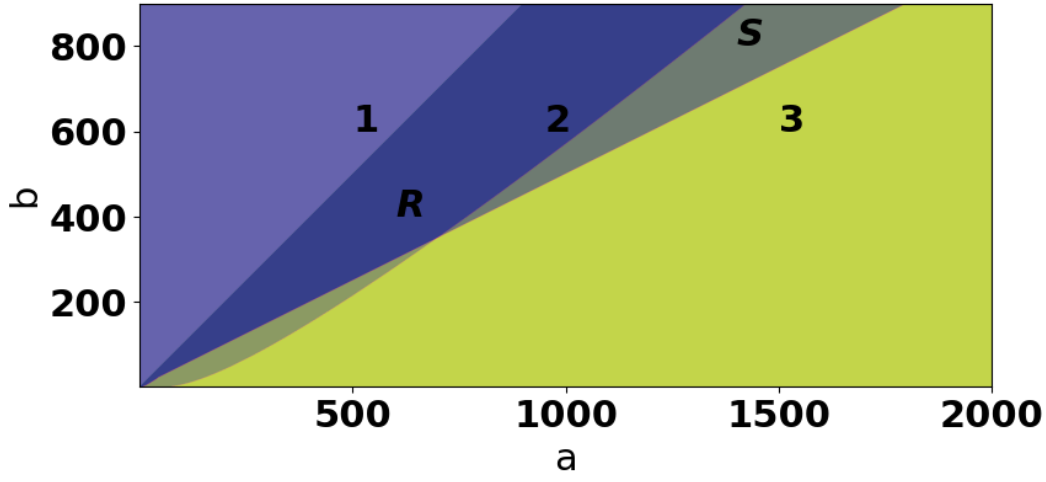
Problem: Given A, recover the communities of the nodes. [1]

[1] Galhotra, S., Mazumdar, A., Pal, S. and Saha, B., 2018, April. The geometric block model. In Proceedings of the AAAI Conference on Artificial Intelligence (Vol. 32, No. 1)

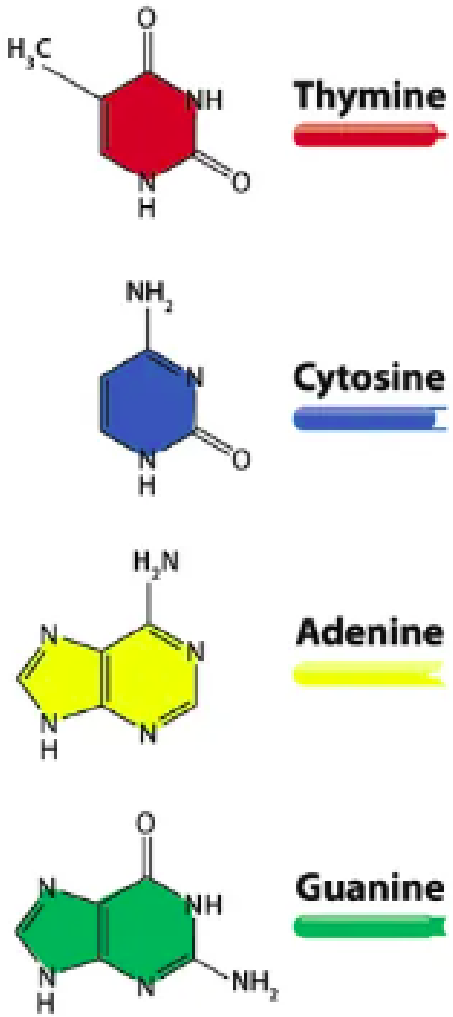
GBM contd...

- Motif counting algorithm
- Datasets: Amazon co-purchase dataset (SNAP), Collaboration network (DBLP, LiveJournal), PoliticalBlogs.
- Necessary conditions: $a - b > \frac{1}{2}$ and $a > 1$
- Semi-supervised: Given A and communities of a fraction ηN number of nodes, recover communities of all nodes.

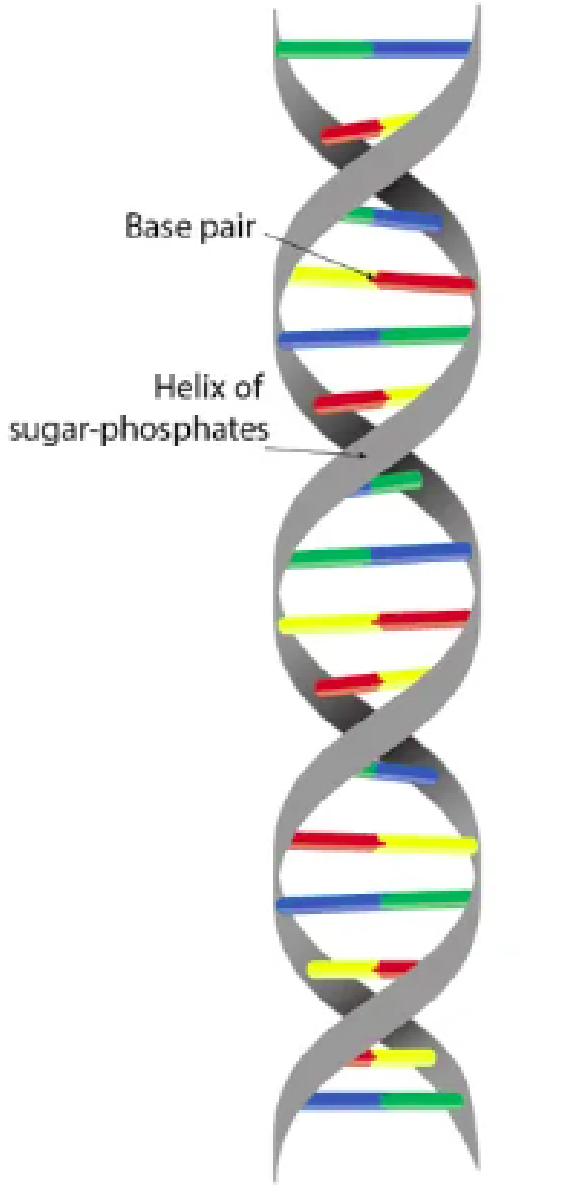




DNA haplotype reconstruction

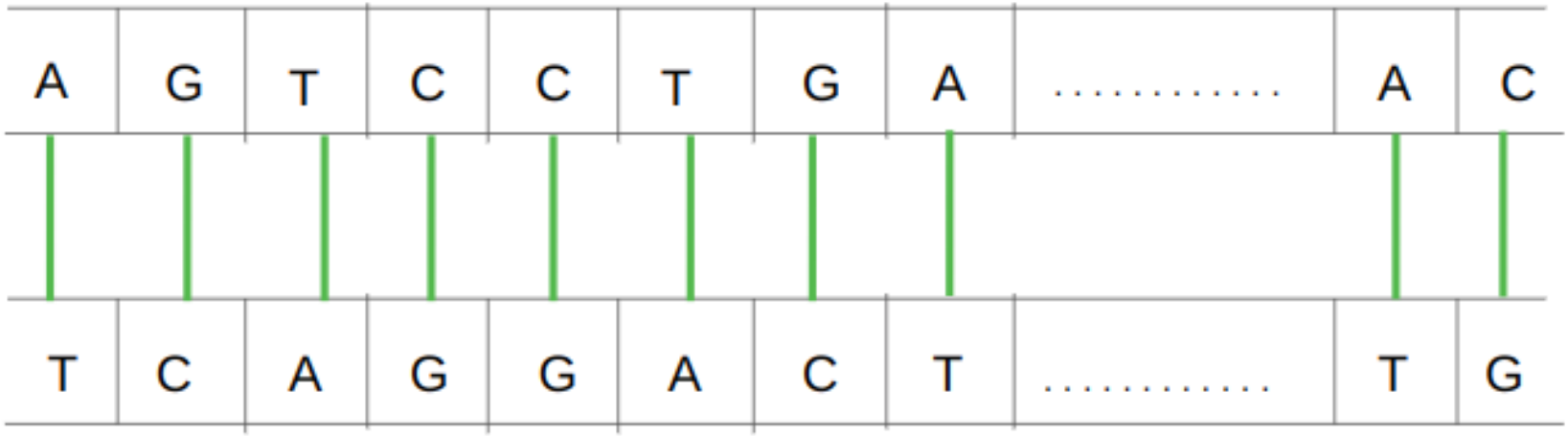


Nucleobases of DNA



DNA
Deoxyribonucleic acid

DNA haplotype reconstruction



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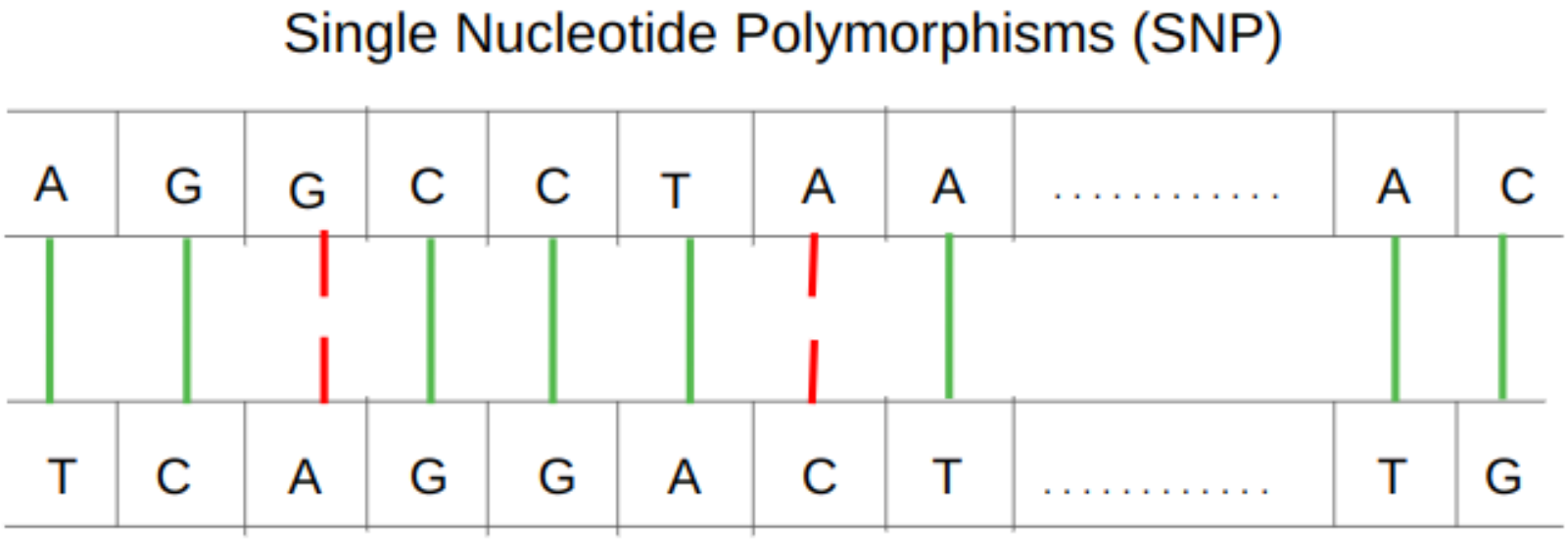

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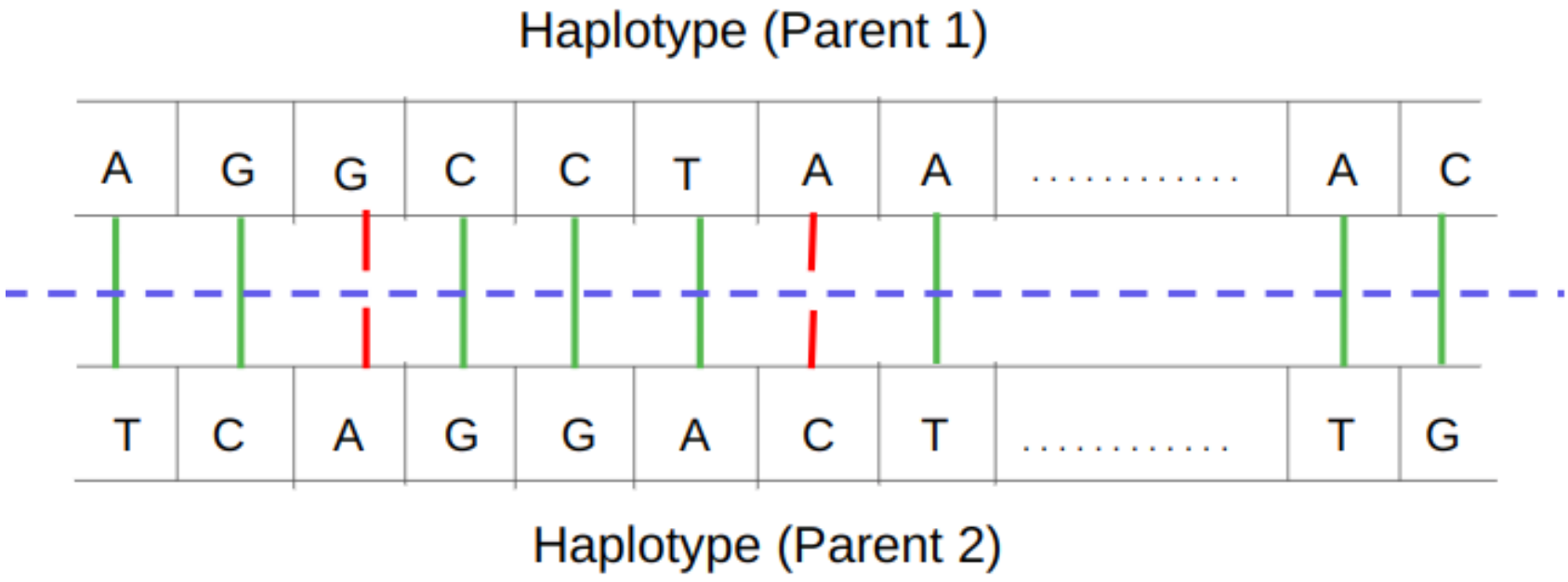

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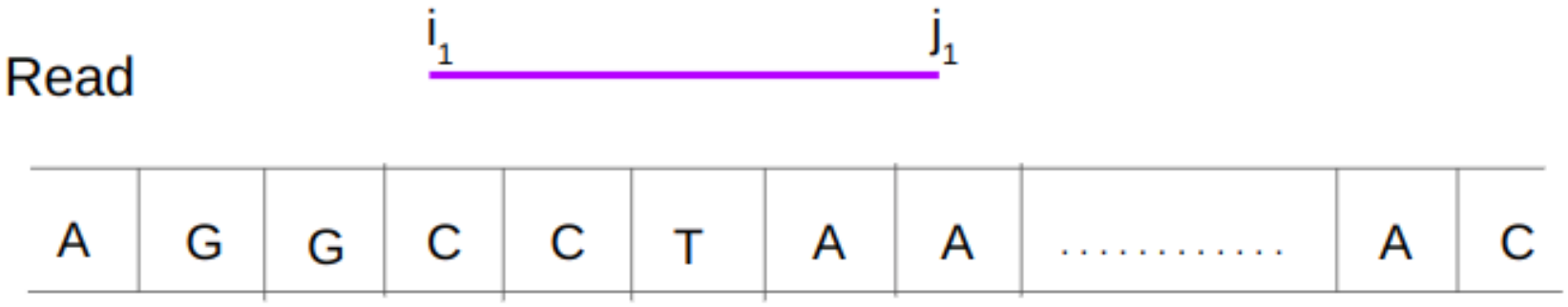

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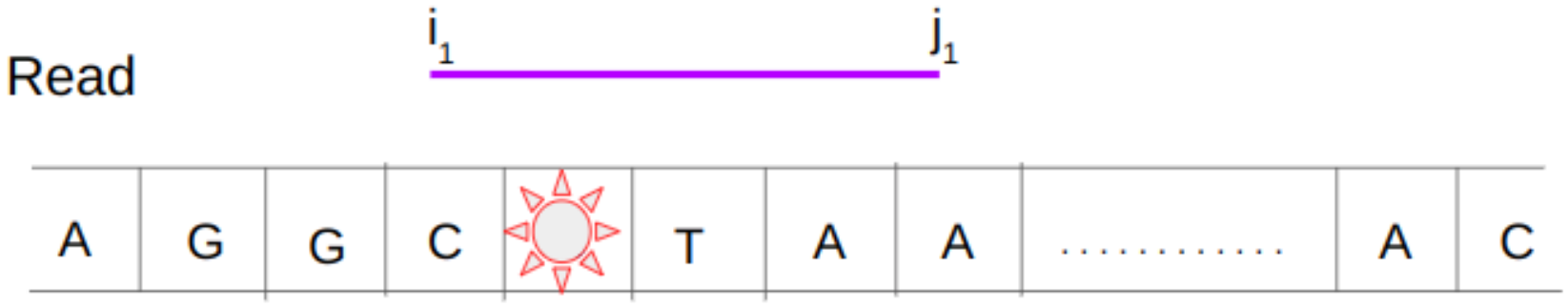

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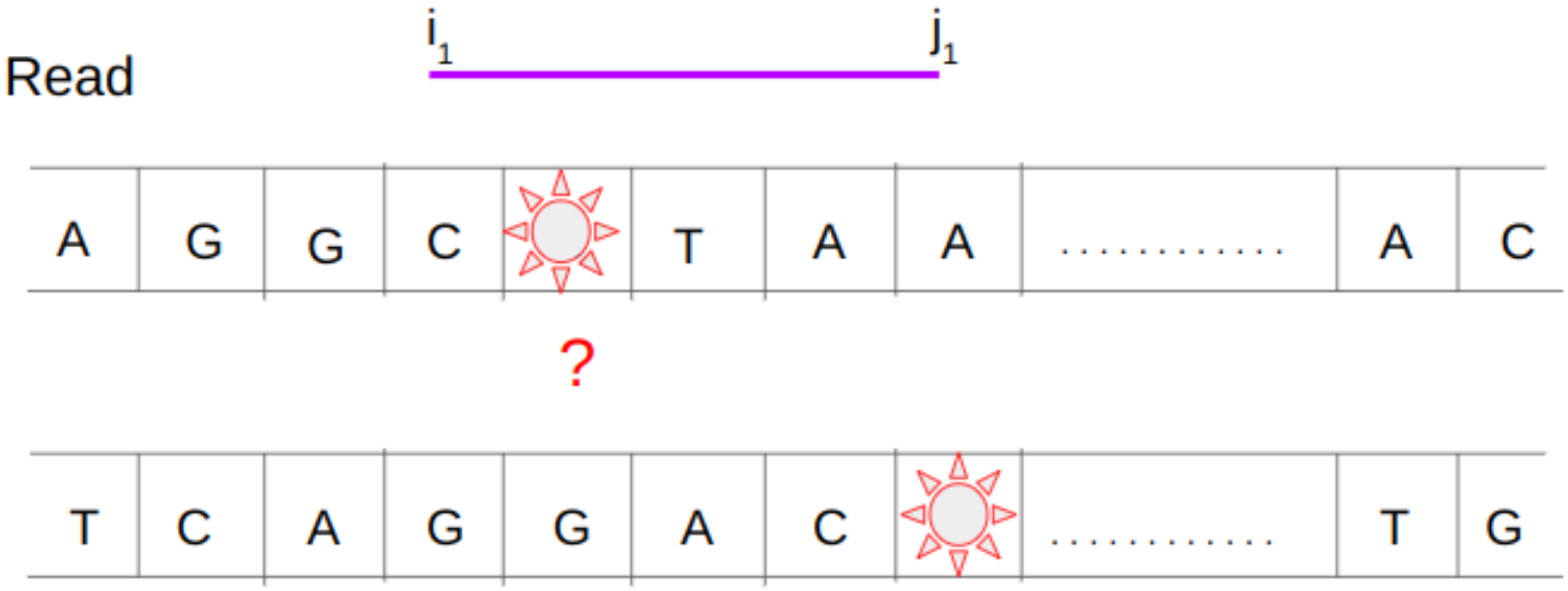

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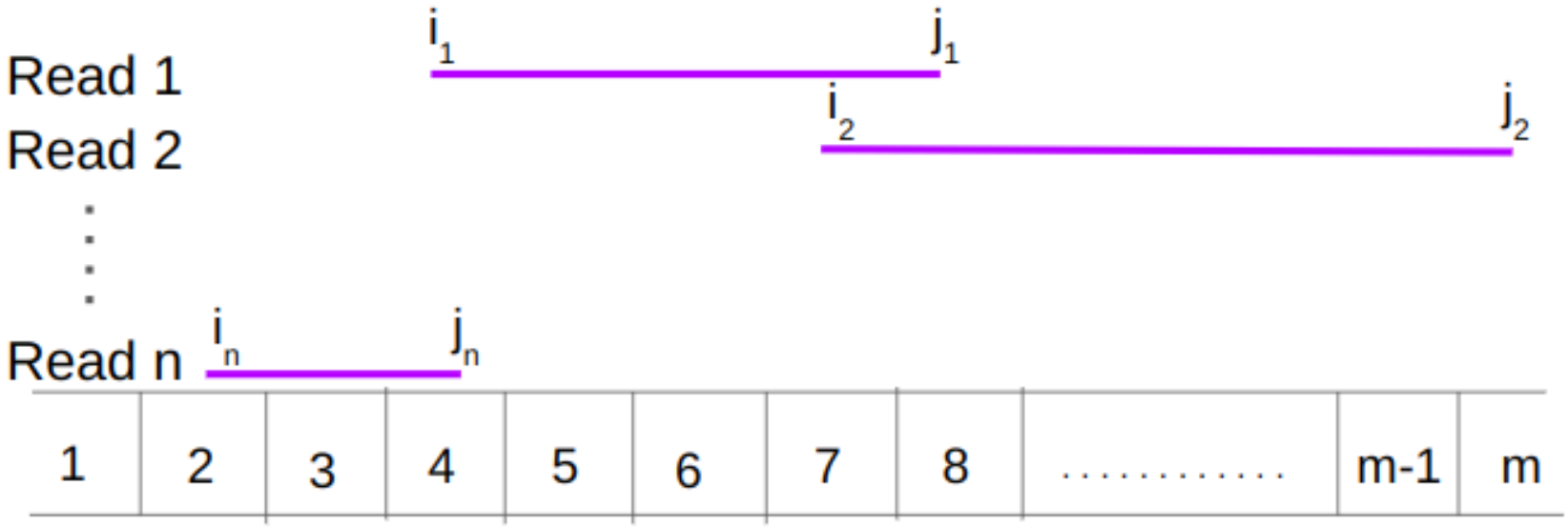
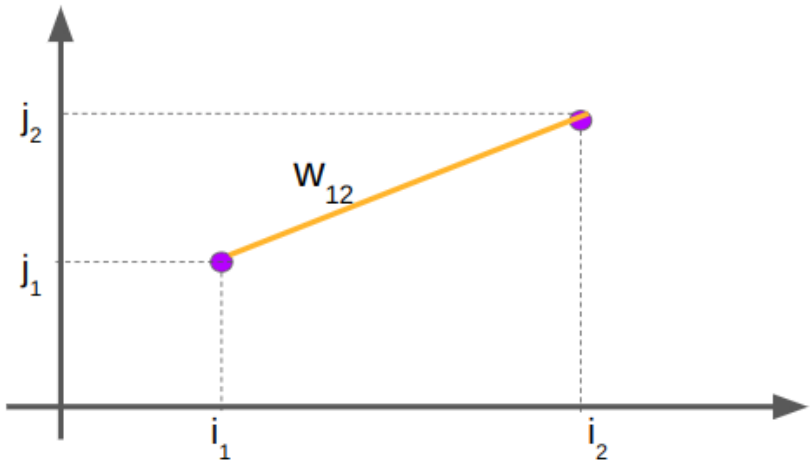




- Edge only if two reads overlap
- S: Matching overlapping sites
- D: Non-matching overlapping sites
- $w_{uv} = \frac{S-D}{S+D}$

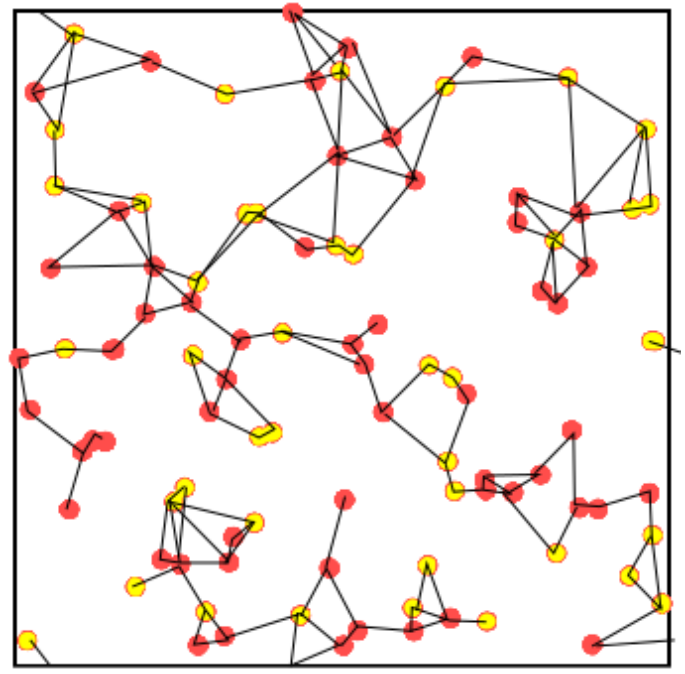
Sankararaman, A., Vikalo, H. and Baccelli, F., 2020. ComHapDet: a spatial community detection algorithm for haplotype assembly. BMC genomics, 21, pp.1-14.

Euclidean random graphs

- N nodes
- Locations: $\mathbf{X} \sim \text{Unif}(B_n)$
- Communities:
  $\boldsymbol{\sigma} : \sigma_i \sim$ Unif $(\{-1, +1\})$

- Probabilities $p, q \in [0, 1]$ with
  $p > q$

- Geometric kernel: $\mathbf{K} = (K_{ij})$, where
  $K_{ij} = K(X_i, X_j)$

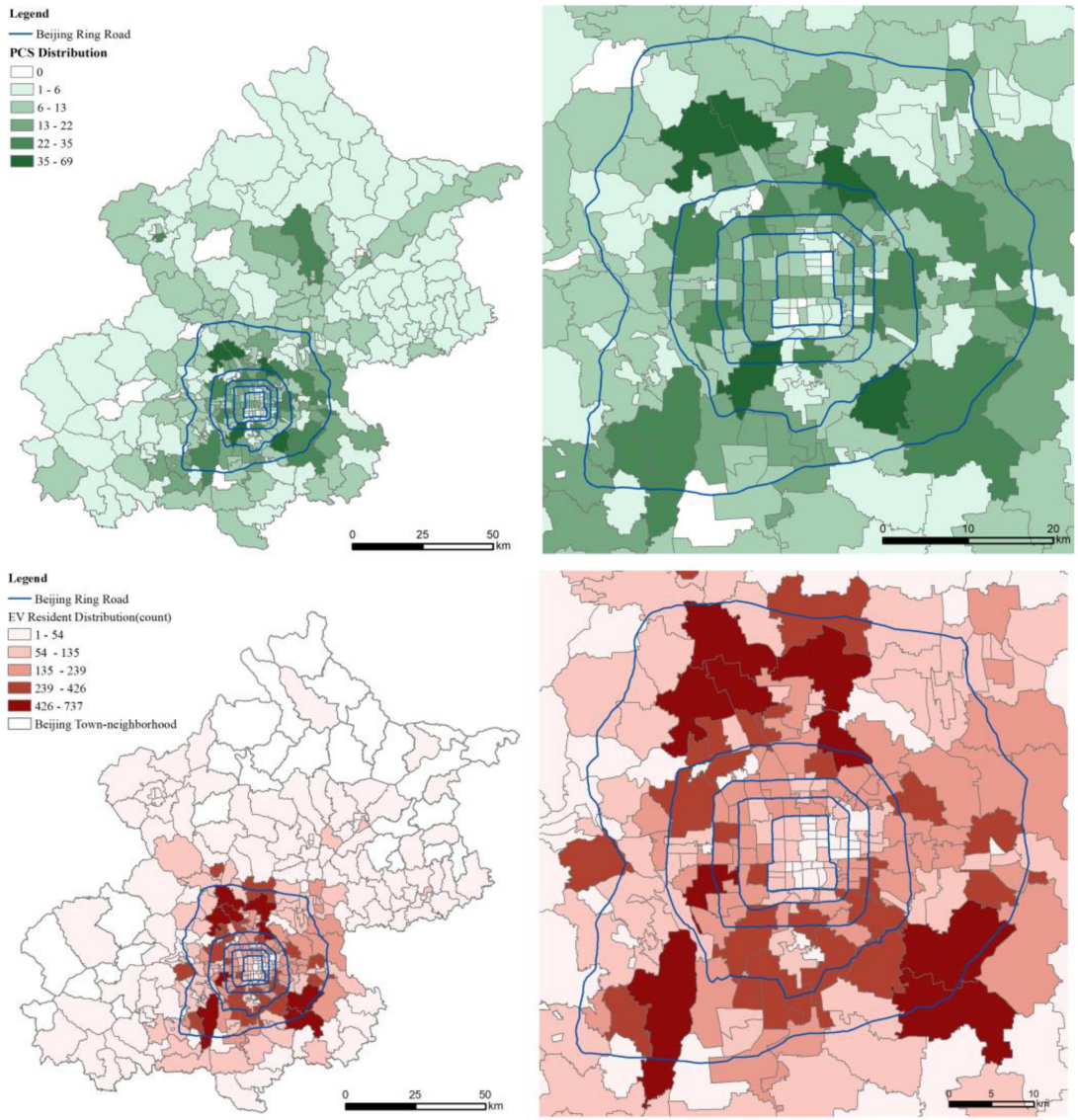


Given locations $\mathbf{X}$ and communities $\boldsymbol{\sigma}$

$$A_{ij} = 1 \begin{cases} \text{with prob. } pK(X_i, X_j) & \text{if } \sigma_i = \sigma_j \\ \text{with prob. } qK(X_i, X_j) & \text{if } \sigma_i \neq \sigma_j \end{cases}$$

$$\mathbf{A} = (A_{ij})_{i,j=1}^{N} \sim GKBM(n, p, q, K)$$

Electric vehicles

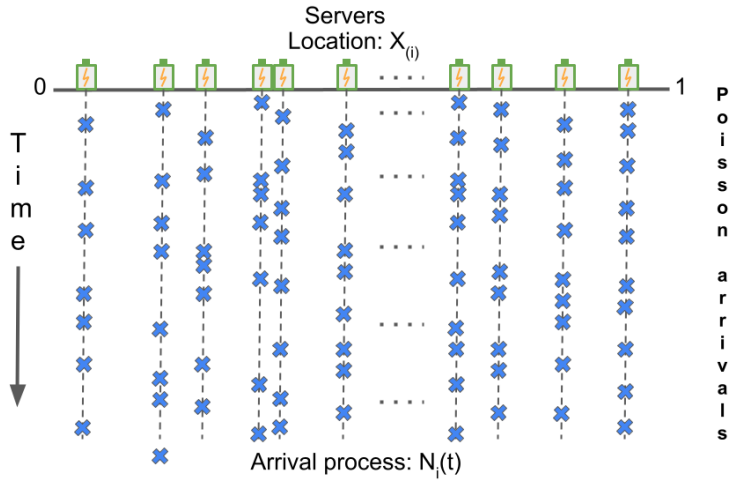


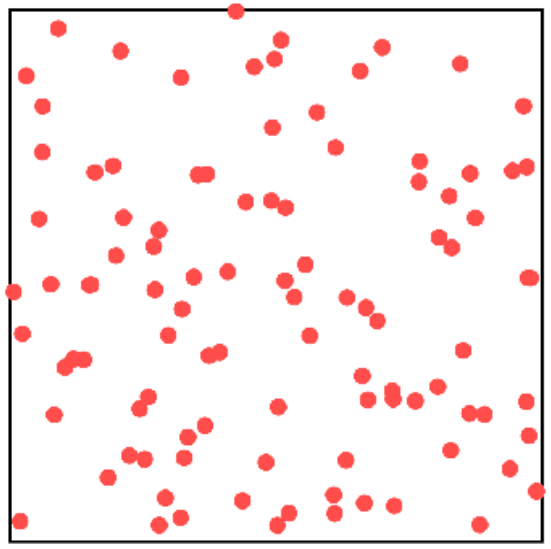
Kang, J., Kan, C. and Lin, Z., 2021. Are electric vehicles reshaping the city? An investigation of the clustering of electric vehicle owners' dwellings and their interaction with urban spaces. ISPRS International Journal

EV Problem formulation

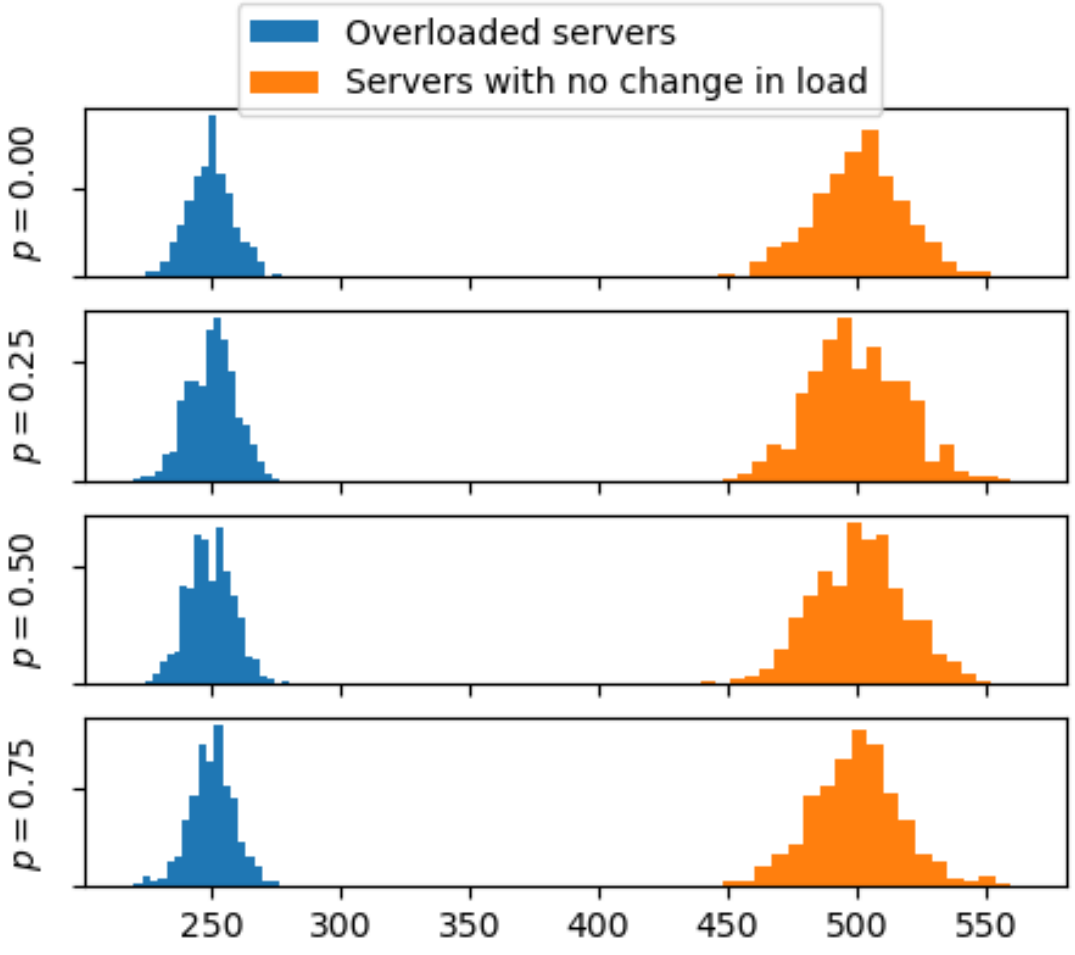
Evaluate load imbalance on EV charging framework induced due to user mobility patterns.

- Charging stations distributed uniformly in $[0, 1]^d$
- Arrival queues of rate λ each
- Arrivals stay in queue with probability p or jump to nearest neighbour with probability $1 - p$ independently
- Problem: Characterize the charging stations that see an arrival rate $> \lambda$.





EVCS distribution



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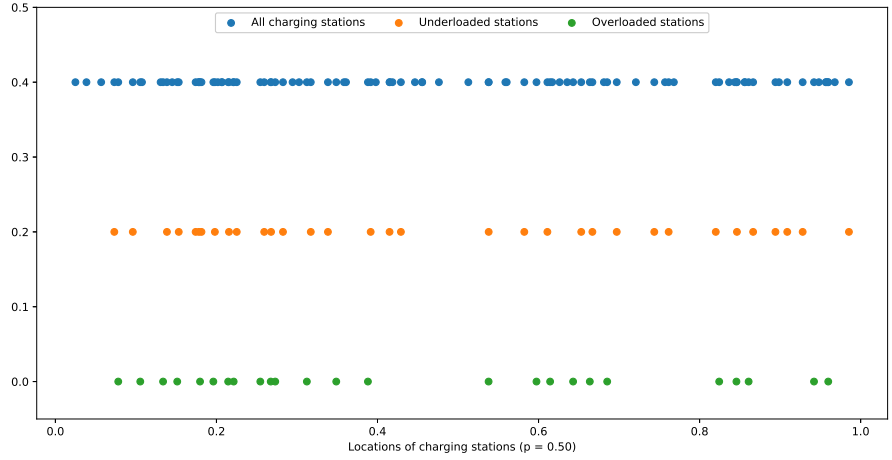
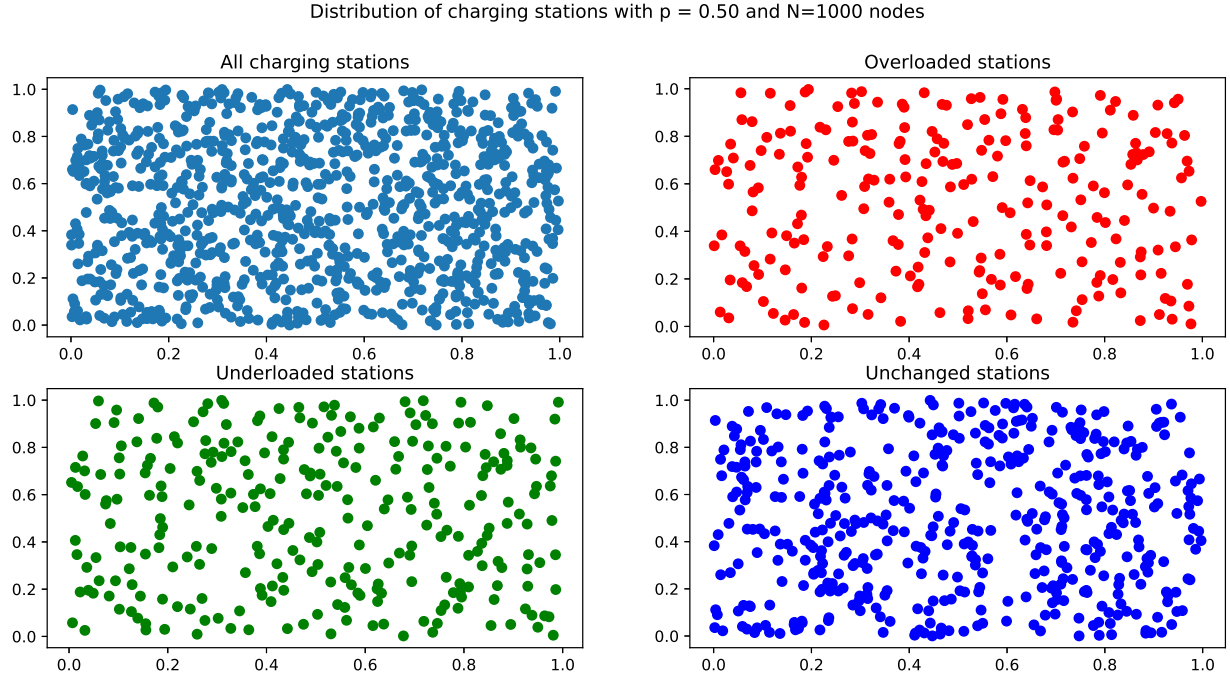
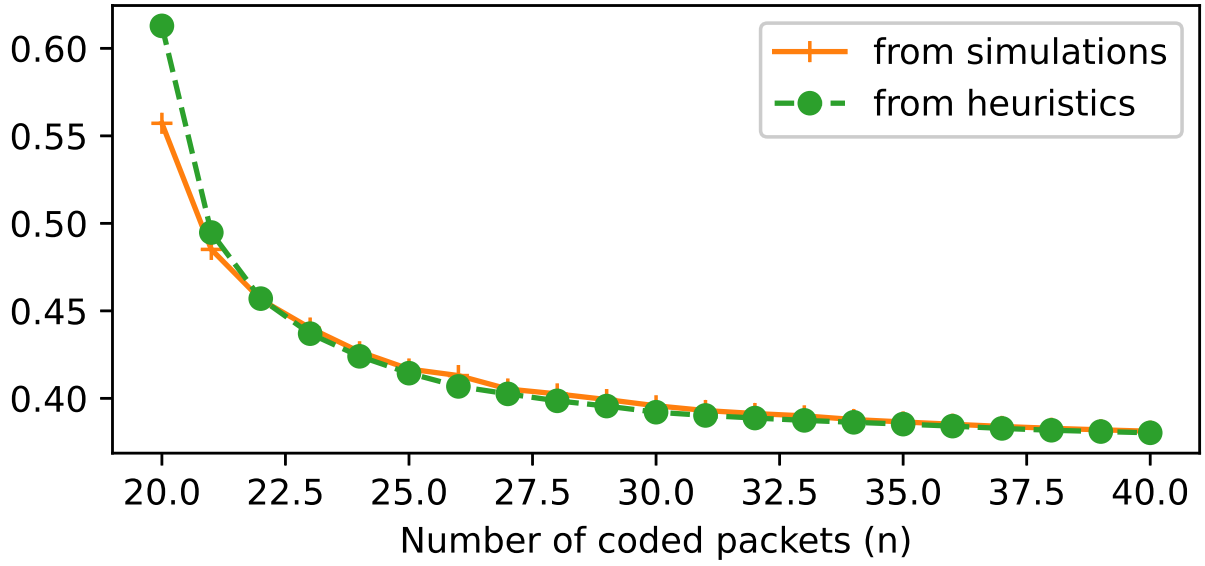
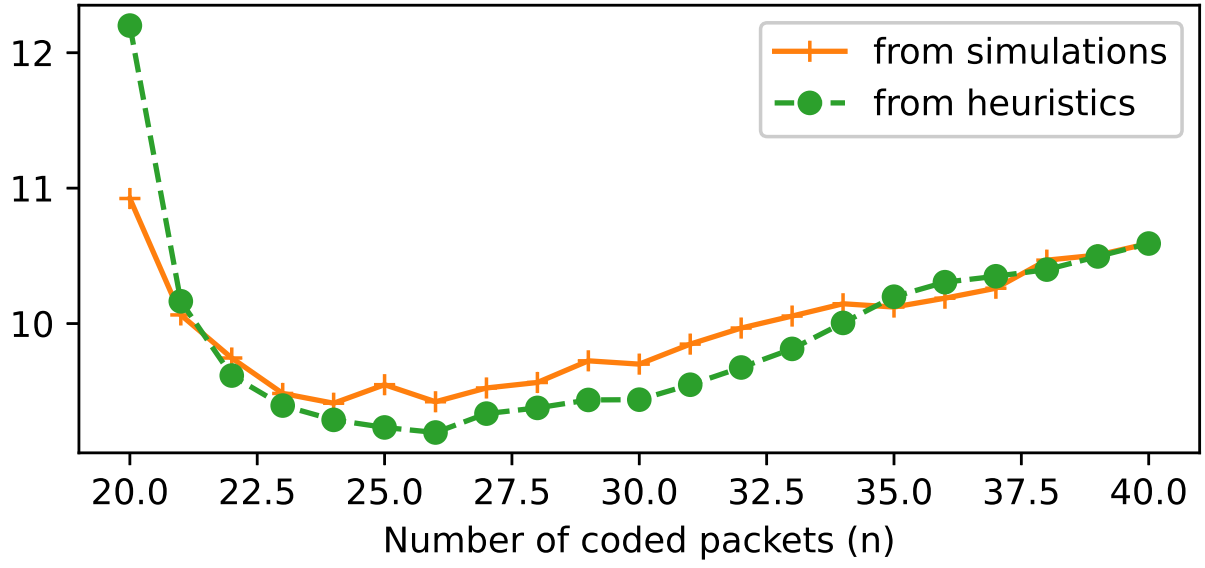




Some videos now !!

Probabilistic forwarding results





Thank you !!