

# Sesión 15.0: Un mundo pequeño

**CS3102 EDA**



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1. Small-world
2. Navigable Small Worlds (NSW)
3. Hierarchical Navigable Small Worlds (HNSW)

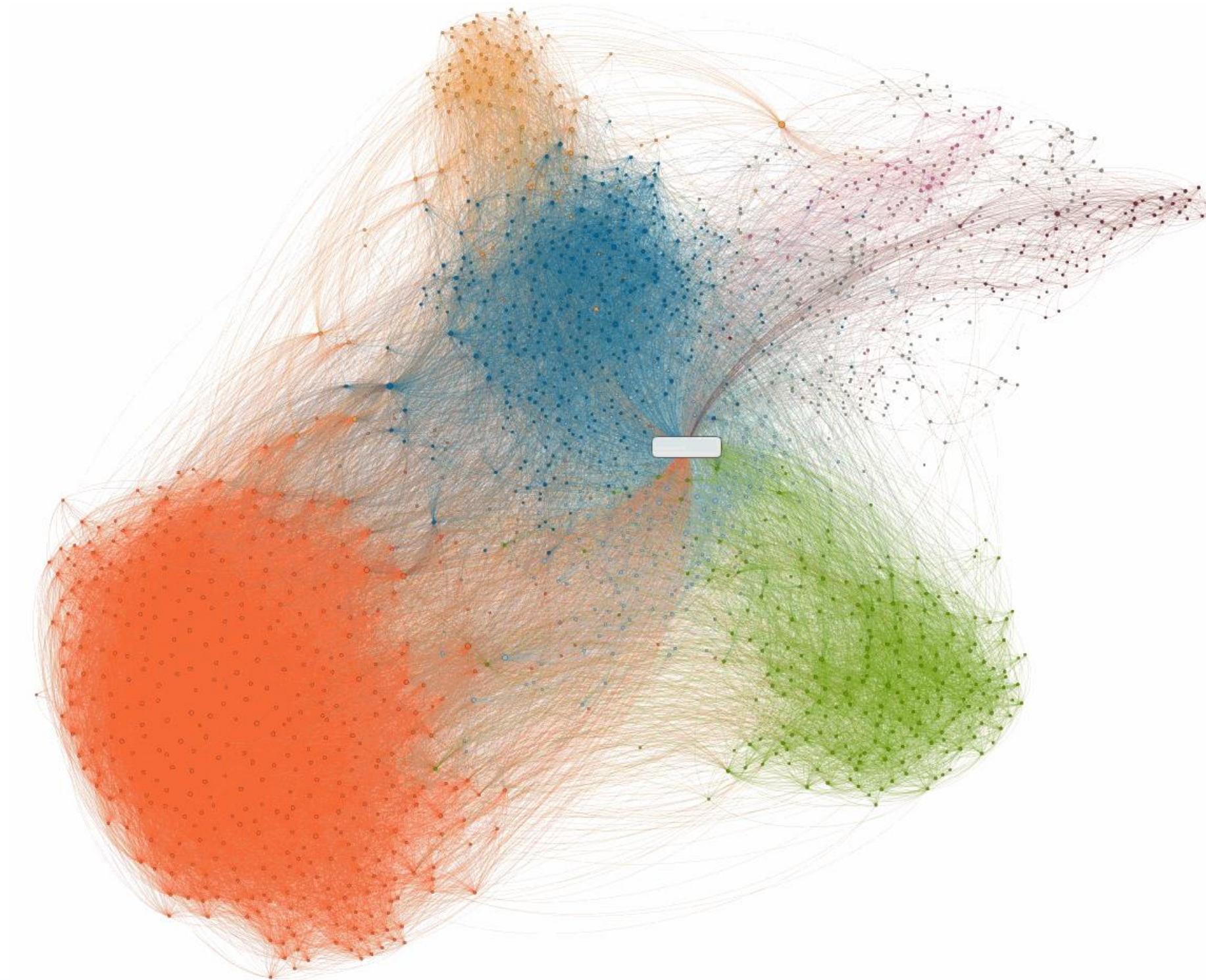




# 1. Small-world

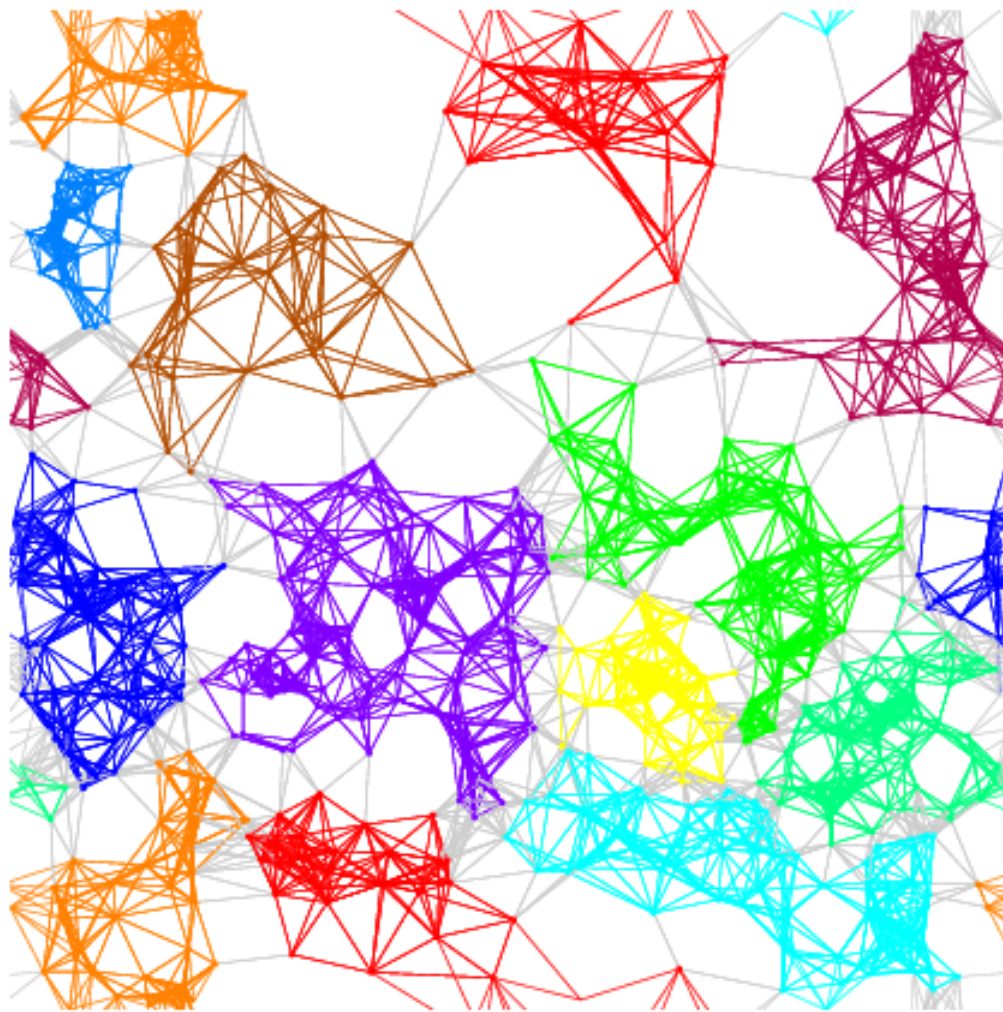


# **Social** *network*



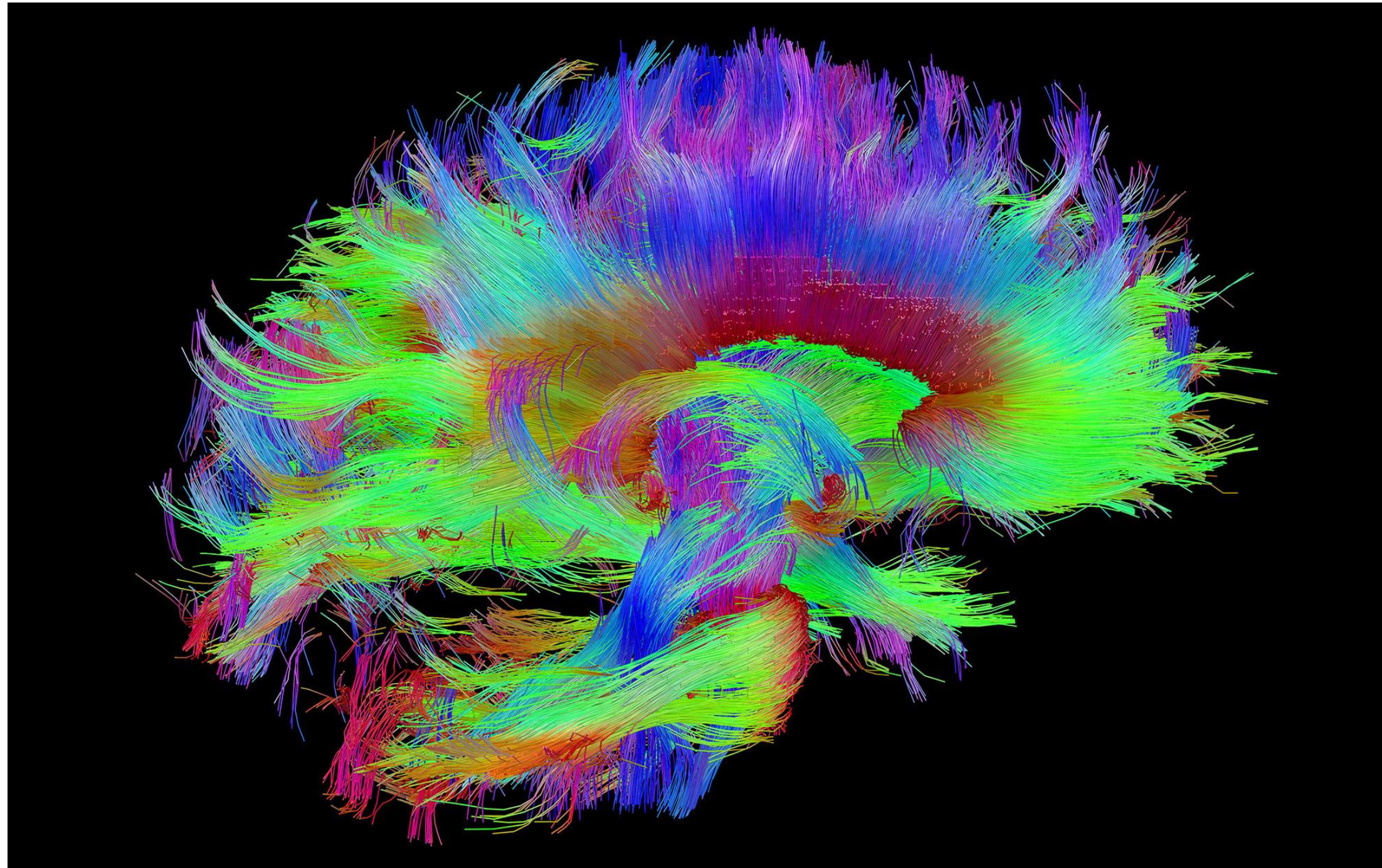


# Peer *to* Peer



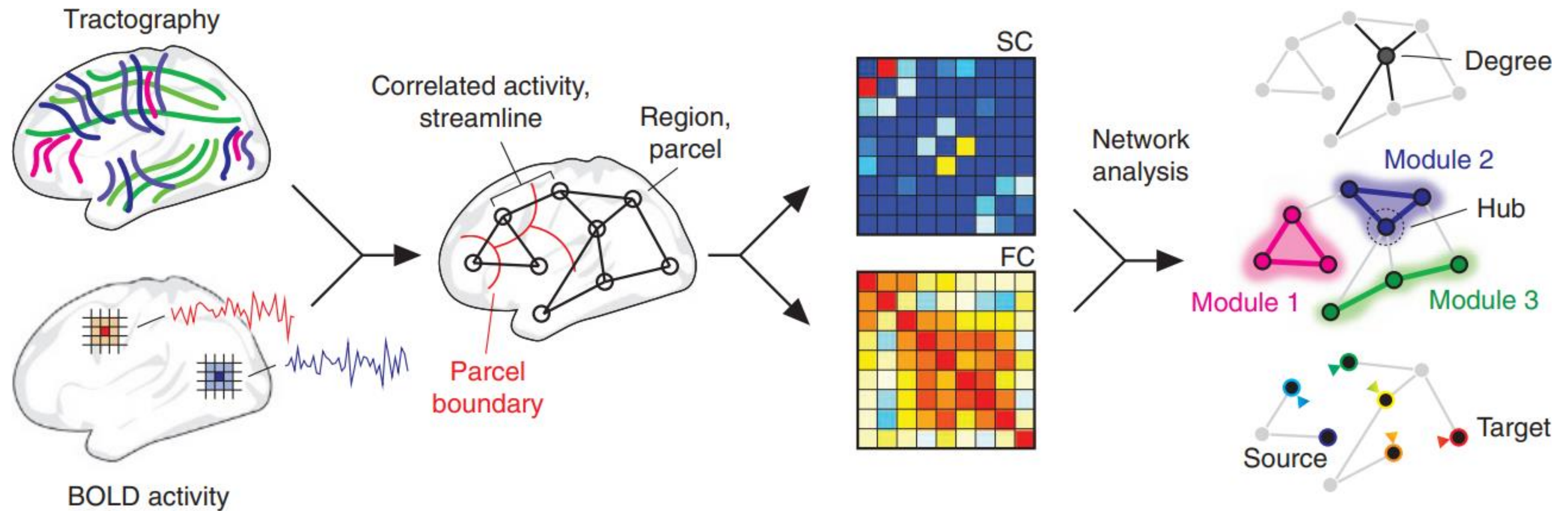


# Neuroscience

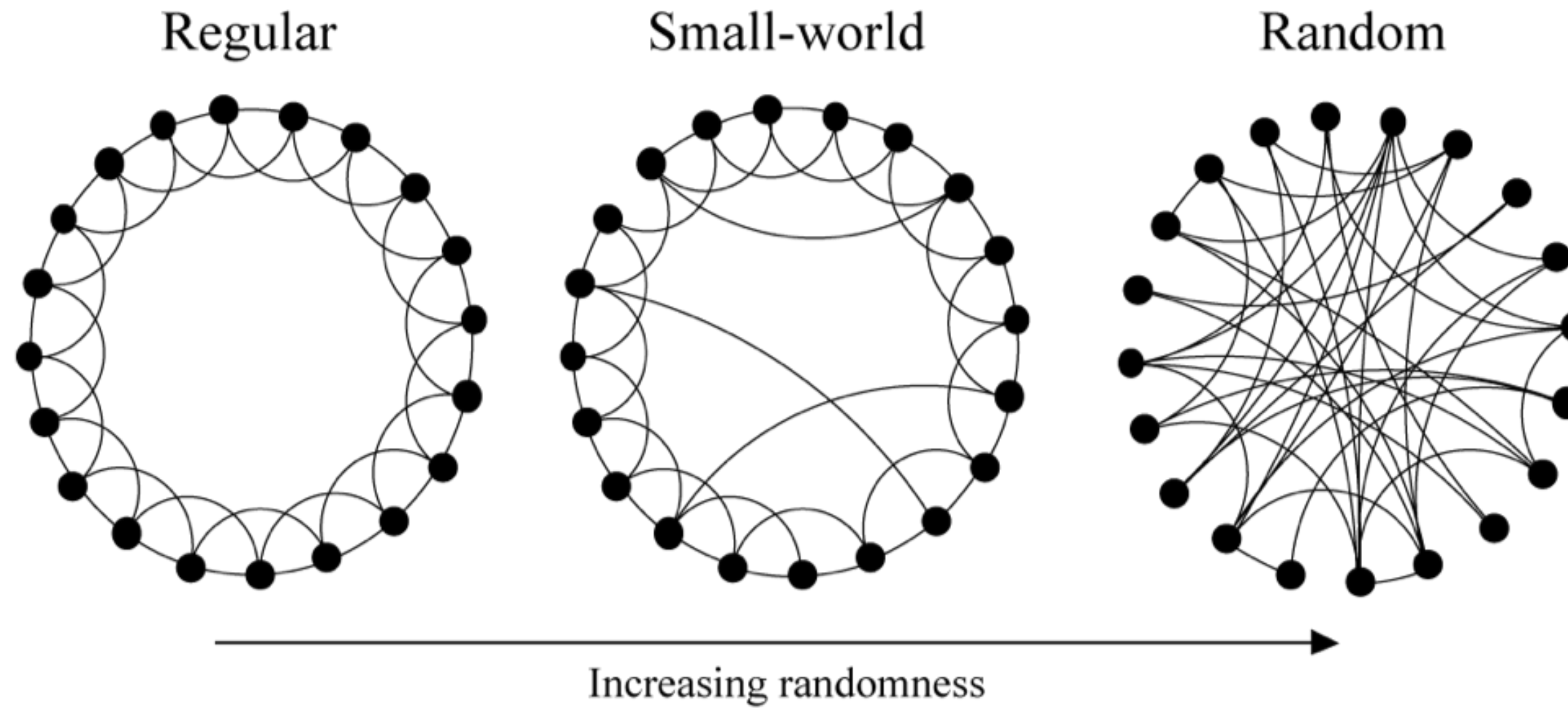




# Neuroscience

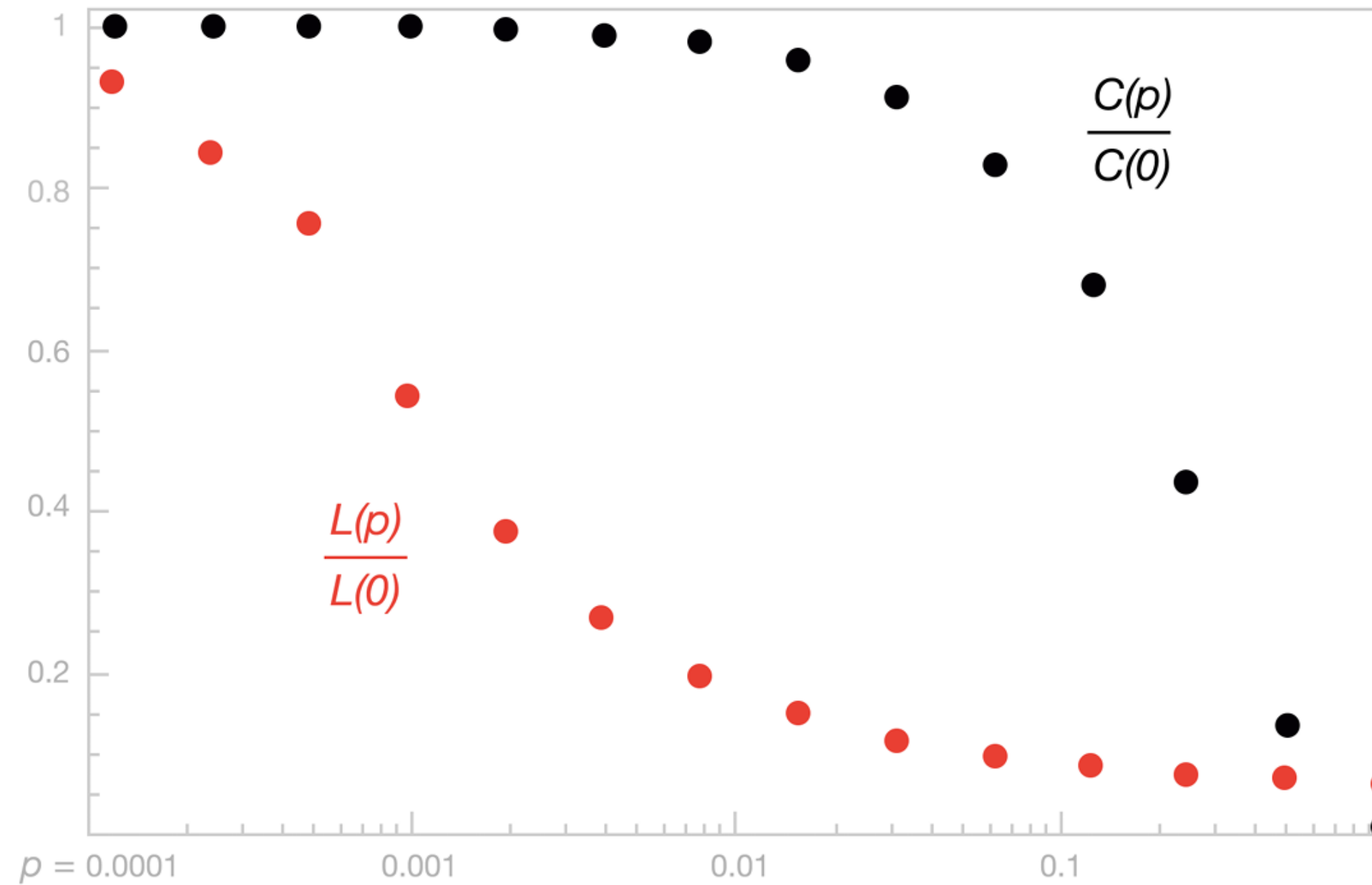


# Small-world



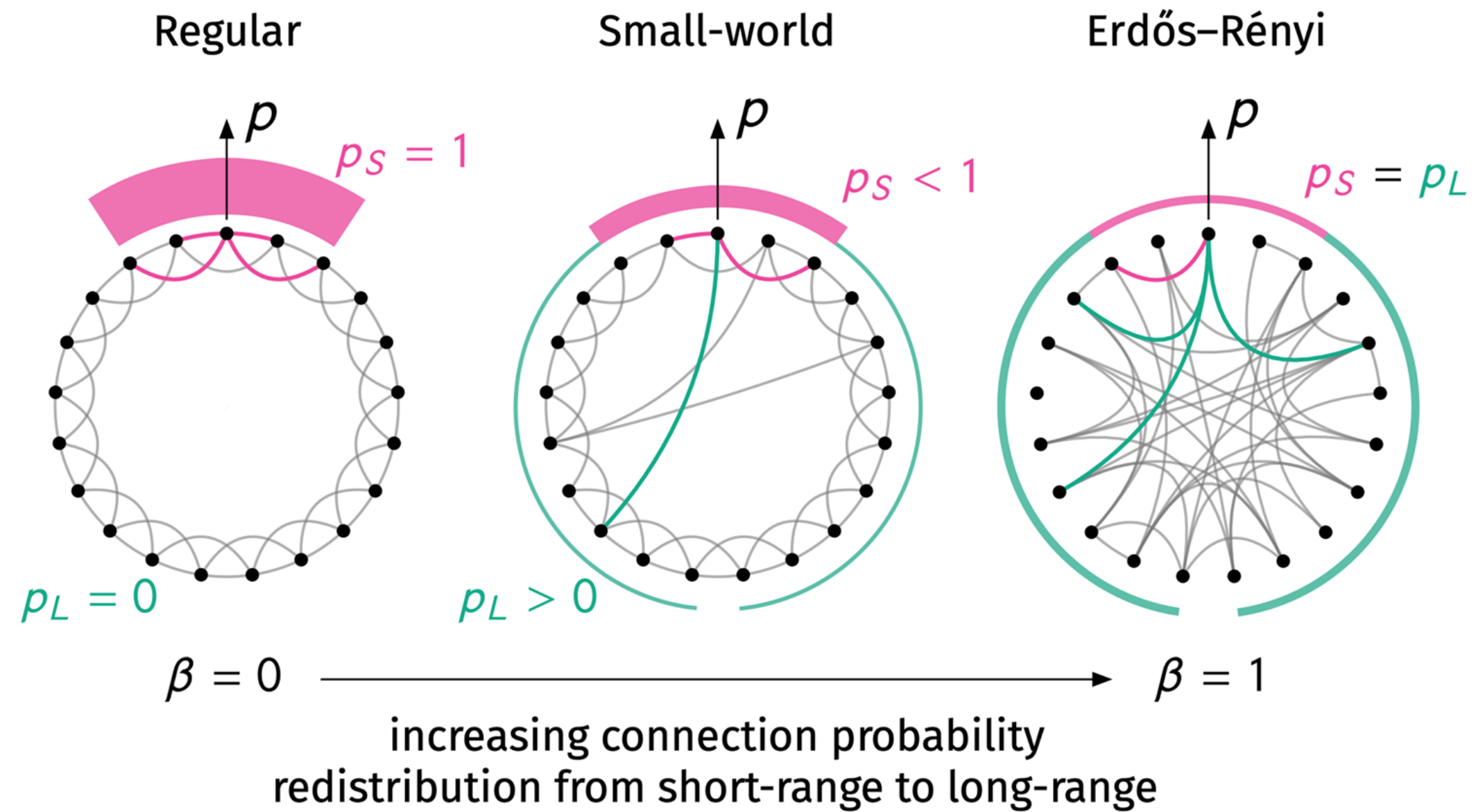


# Small-world





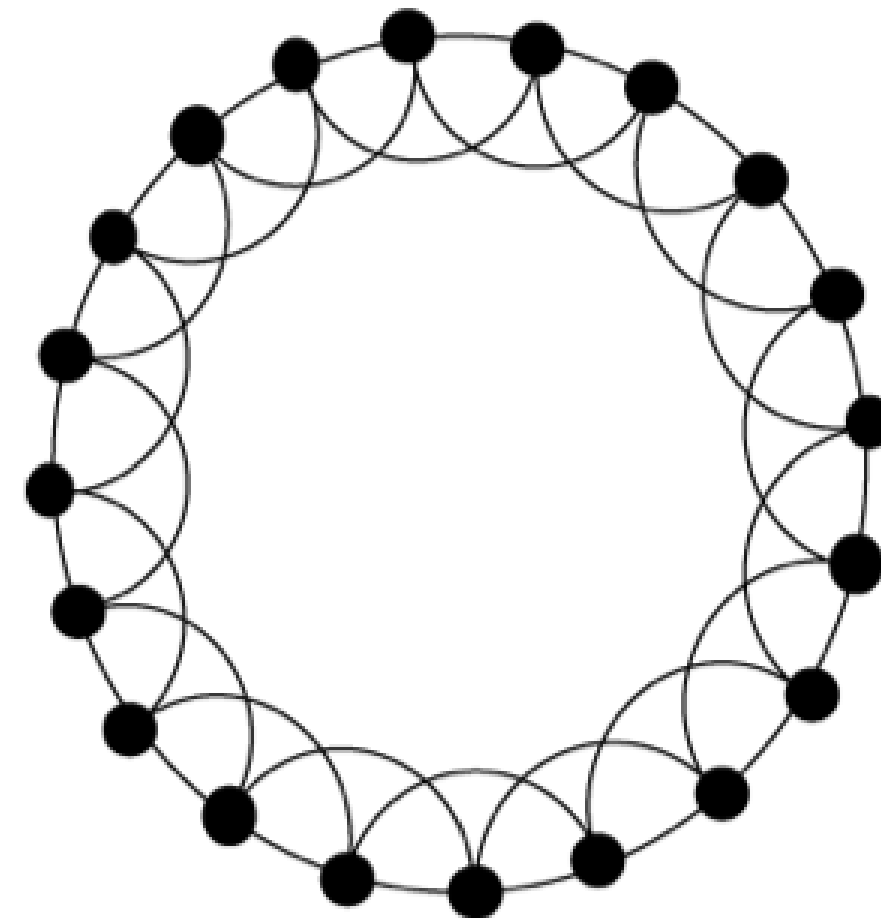
# Small-world





# Watts–Strogatz *model*

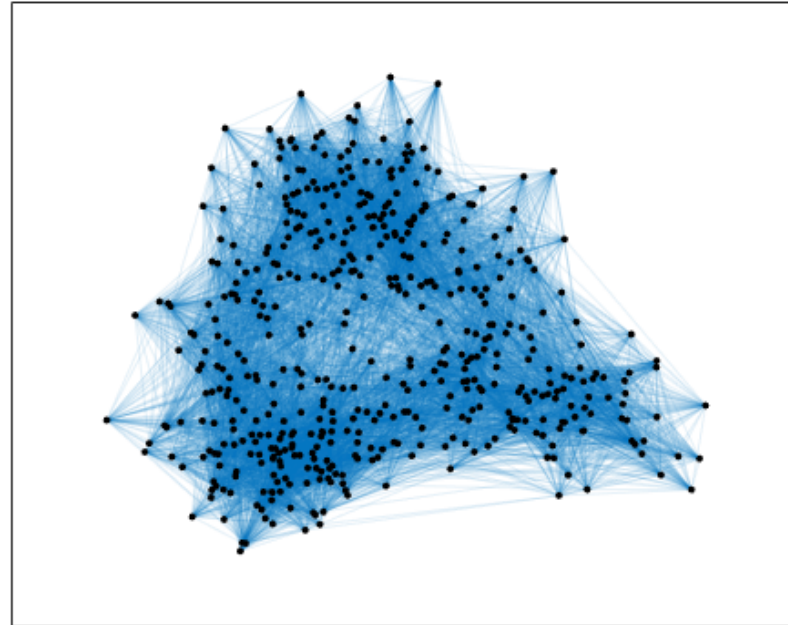
- $N$  es la cantidad de nodos del grafo.
- $k$  es la cantidad de enlaces entre nodos locales.
- $\beta$  es la probabilidad de un enlace entre nodos distantes.



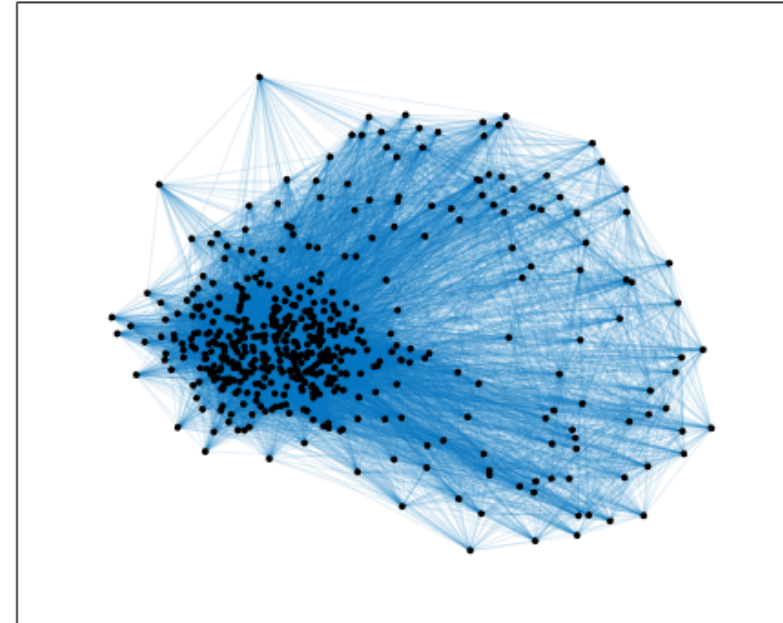


# Social network

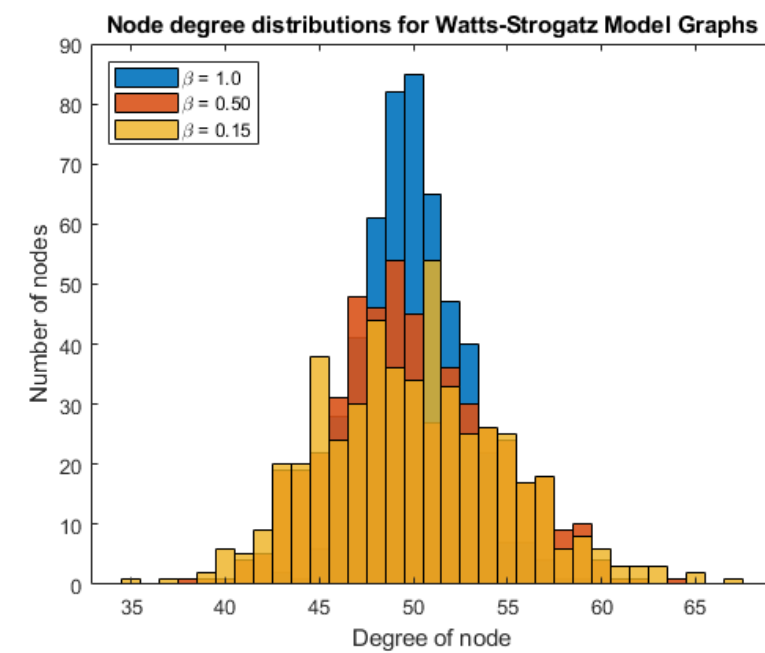
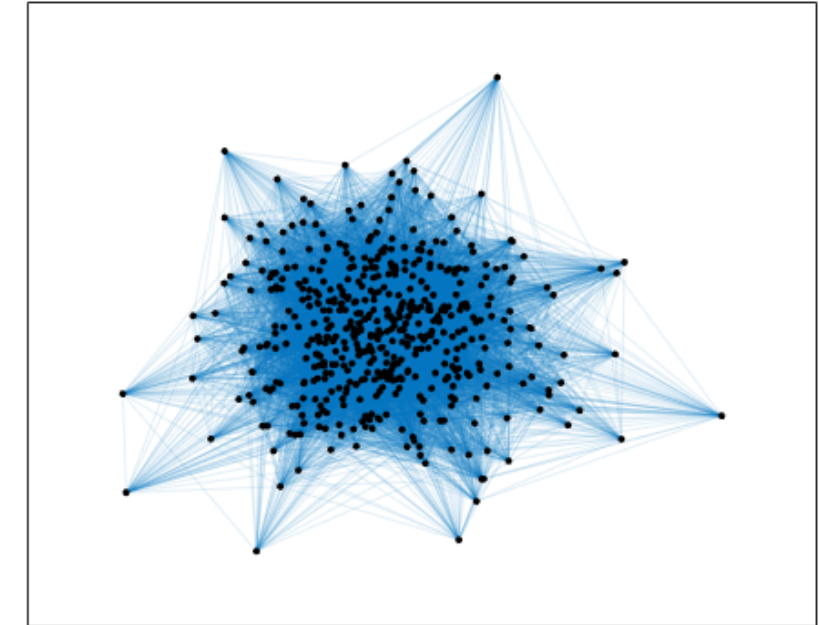
Watts-Strogatz Graph with  $N = 500$  nodes,  $K = 25$ , and  $\beta = 0.15$



Watts-Strogatz Graph with  $N = 500$  nodes,  $K = 25$ , and  $\beta = 0.50$

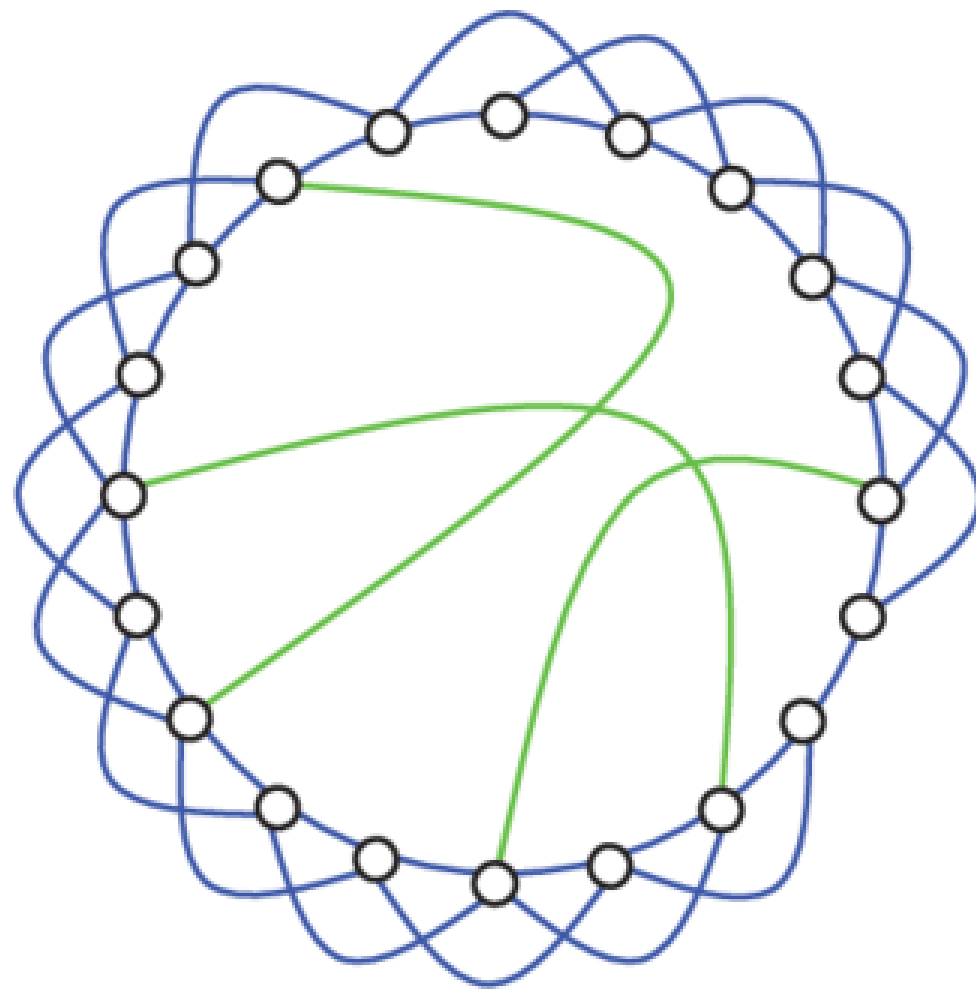


Watts-Strogatz Graph with  $N = 500$  nodes,  $K = 25$ , and  $\beta = 1$

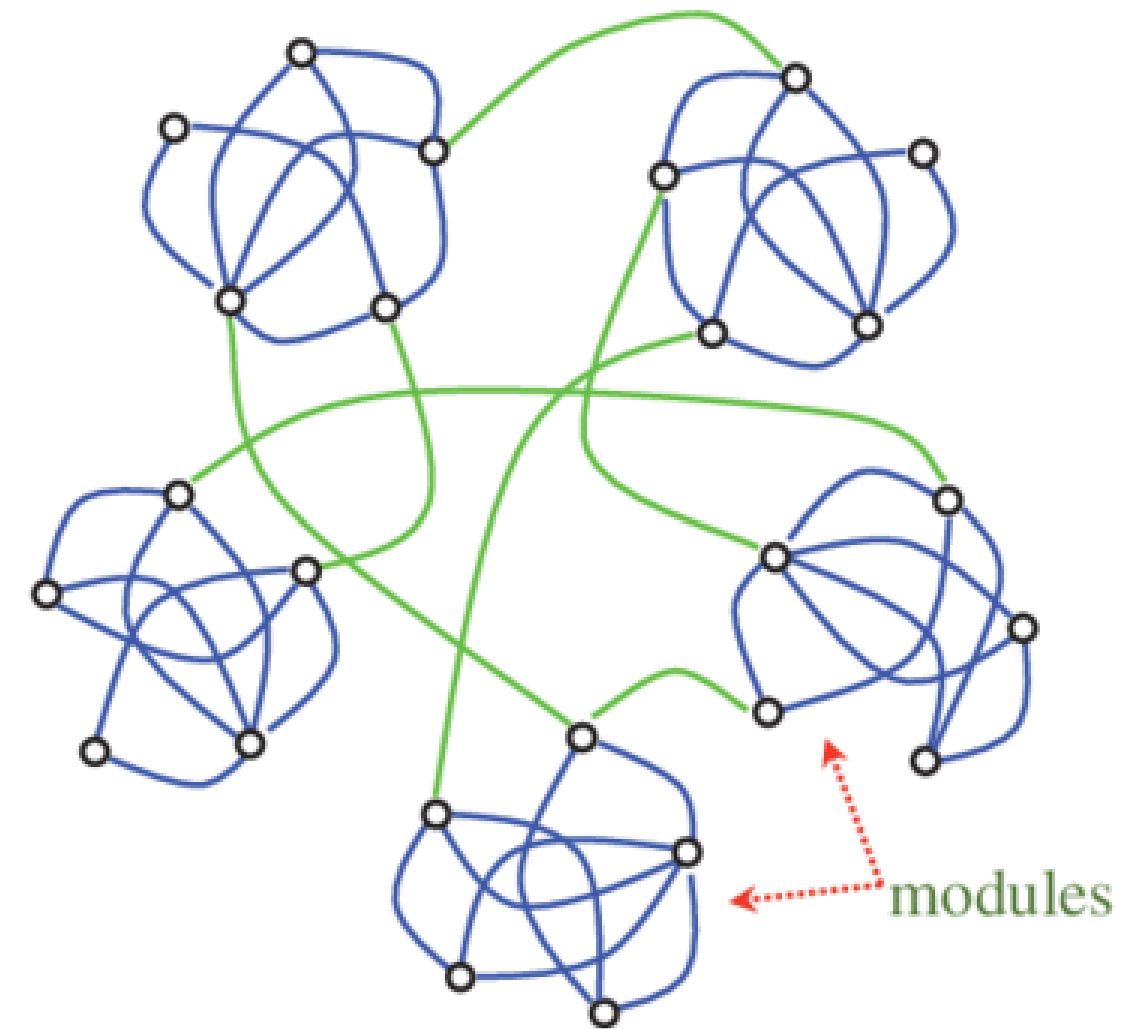




# Watts-Strogatz *model*

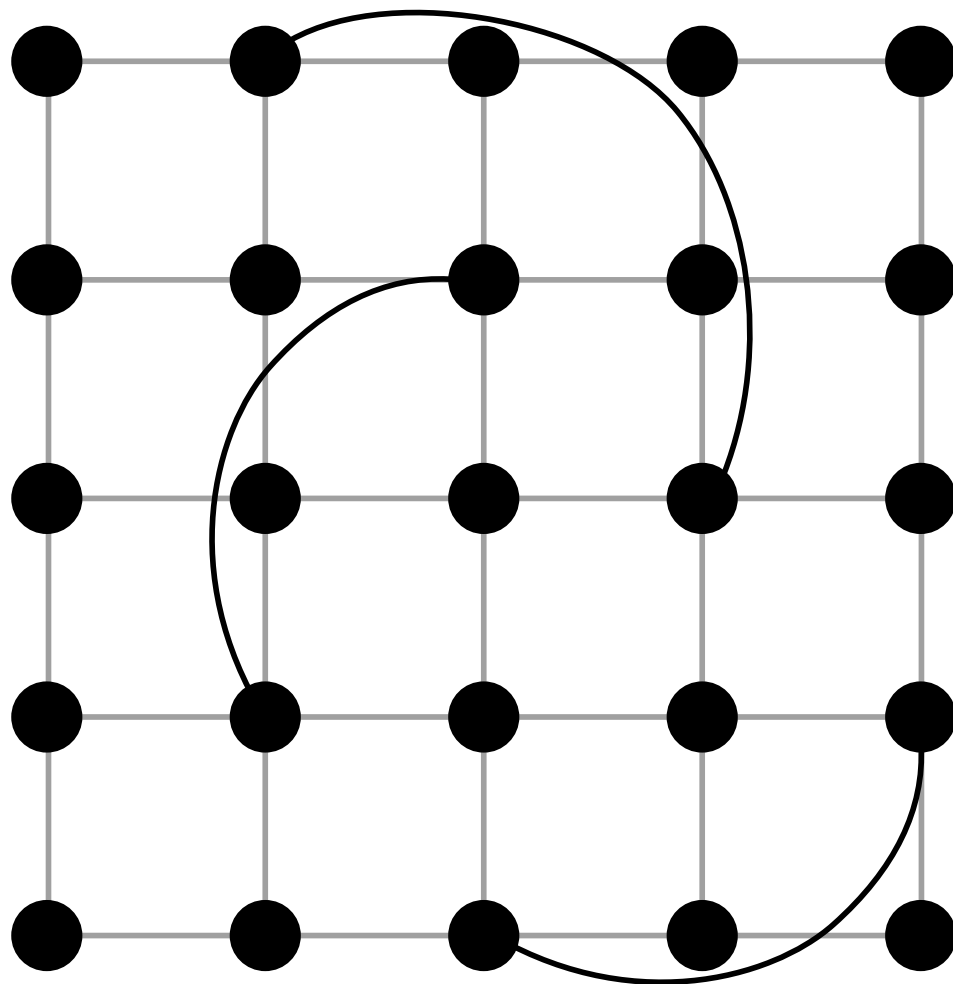


Watts-Strogatz model



Real small-world

# Kleinberg *model*



## Enlaces de corto alcance :

Depende de la cuadrícula.

Podemos utilizar cuadrículas con dimensión 1,2,3,...

## Enlaces de largo alcance :

La probabilidad de que dos nodos tengan un enlace de largo alcance:

$$P(u \rightarrow v) = \frac{1}{Z} d(u, v)^{-r}$$

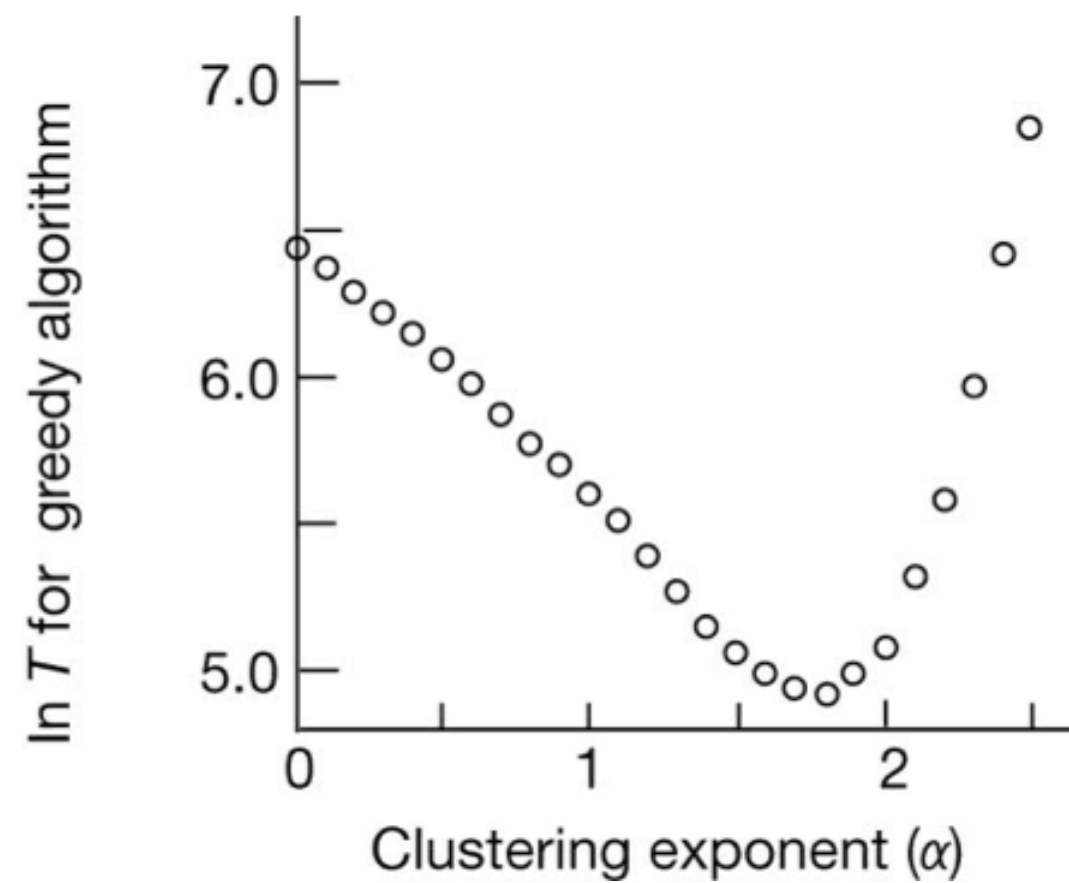
donde  $r$  es el exponente de agrupación.

$d(u, v)$  es la distancia Manhattan entre  $u$  y  $v$ .

$$Z = \sum_{\forall i \neq u} d(u, i)^{-r} \quad \text{coeficiente de normalización por suma}$$



# Kleinberg *model*



- $r = 0$  Similar a un *uniform random graph*
- $r = d$  Óptimo
- $r < d$  Tendemos a seleccionar vecinos lejanos
- $r > d$  Tendemos a seleccionar vecinos cercanos

# Kleinberg *model*

Kleinberg's Model

$$O((\log n)^2)$$

Watts-Strogatz Model

$$O(n^{\frac{2}{3}})$$

Erdos-Renyi Model

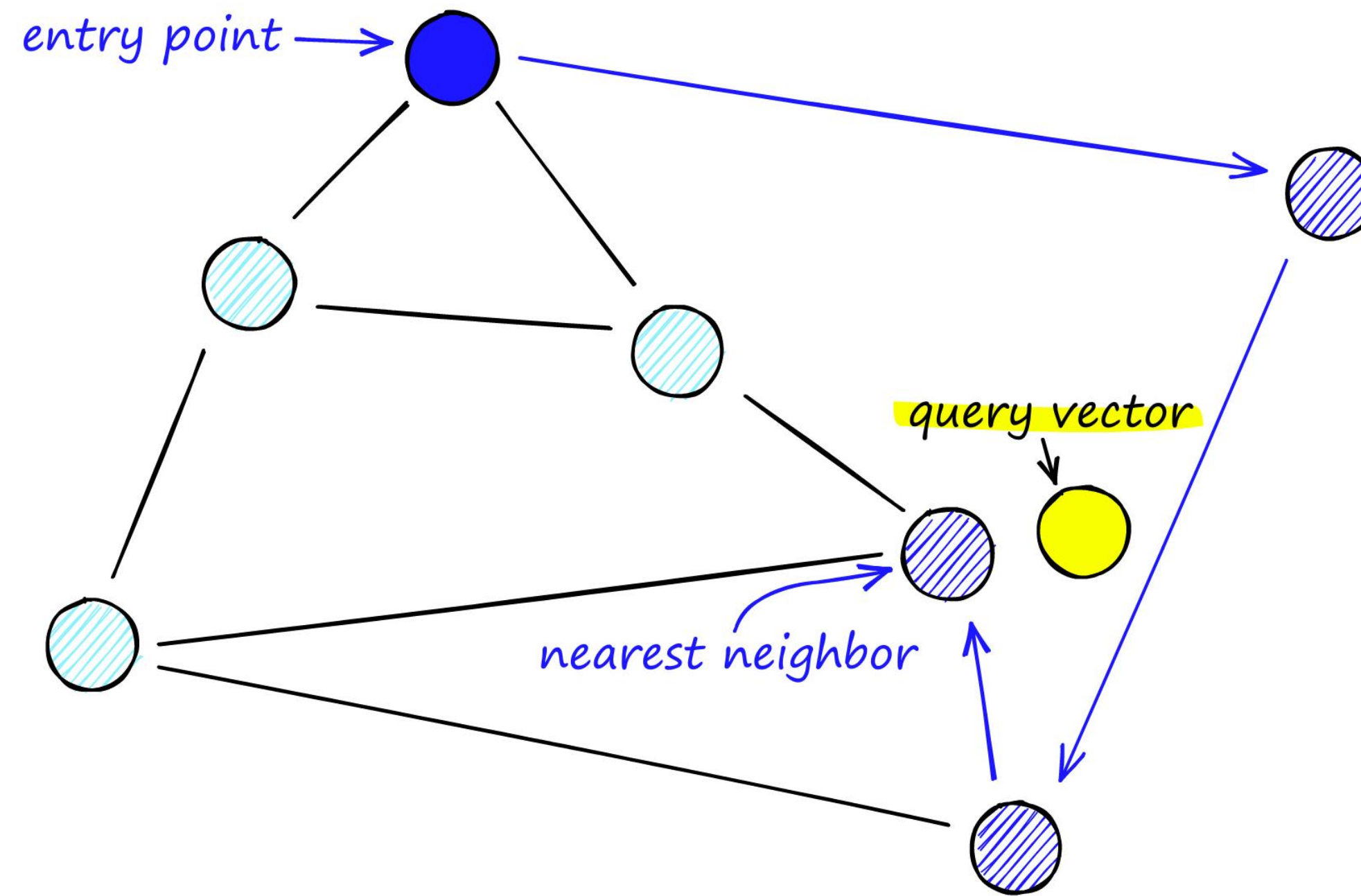
$$O(n)$$



# 2. Navigable Small Worlds (NSW)

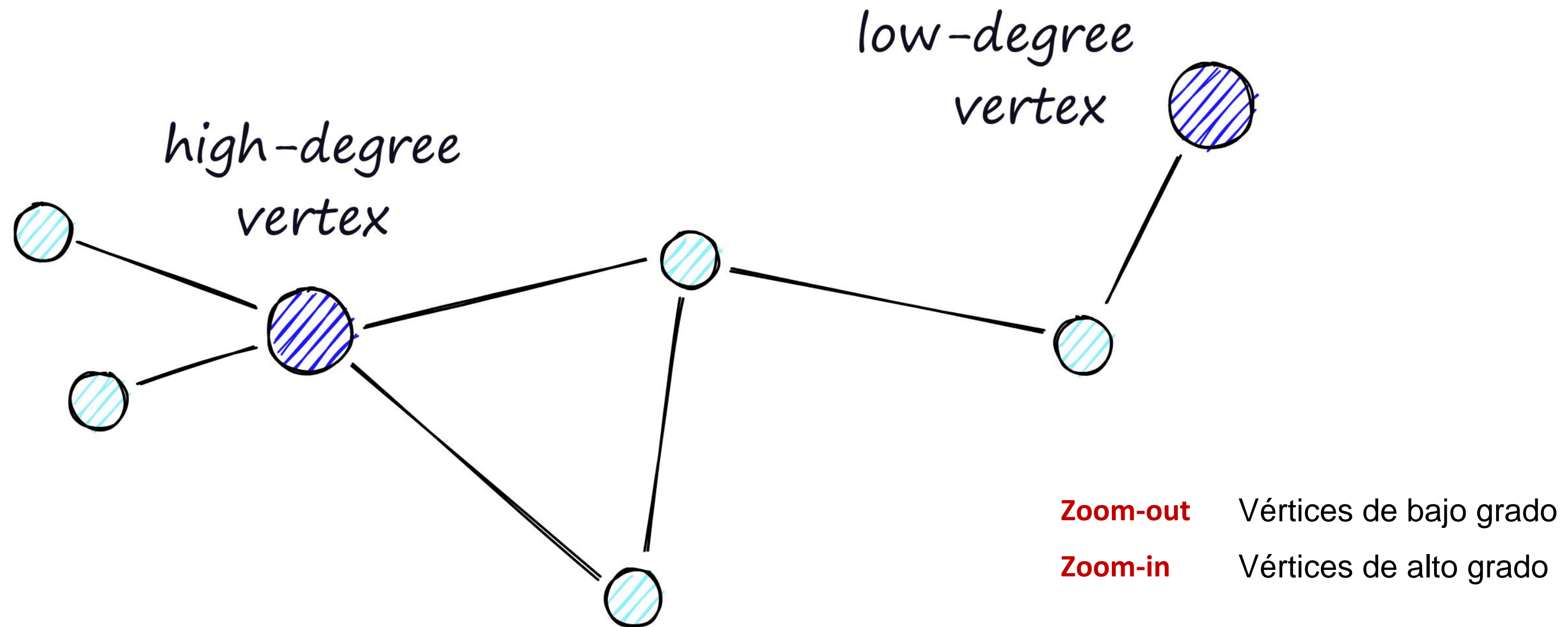


# Navigable Small Worlds (NSW)





# Navigable Small Worlds (NSW)



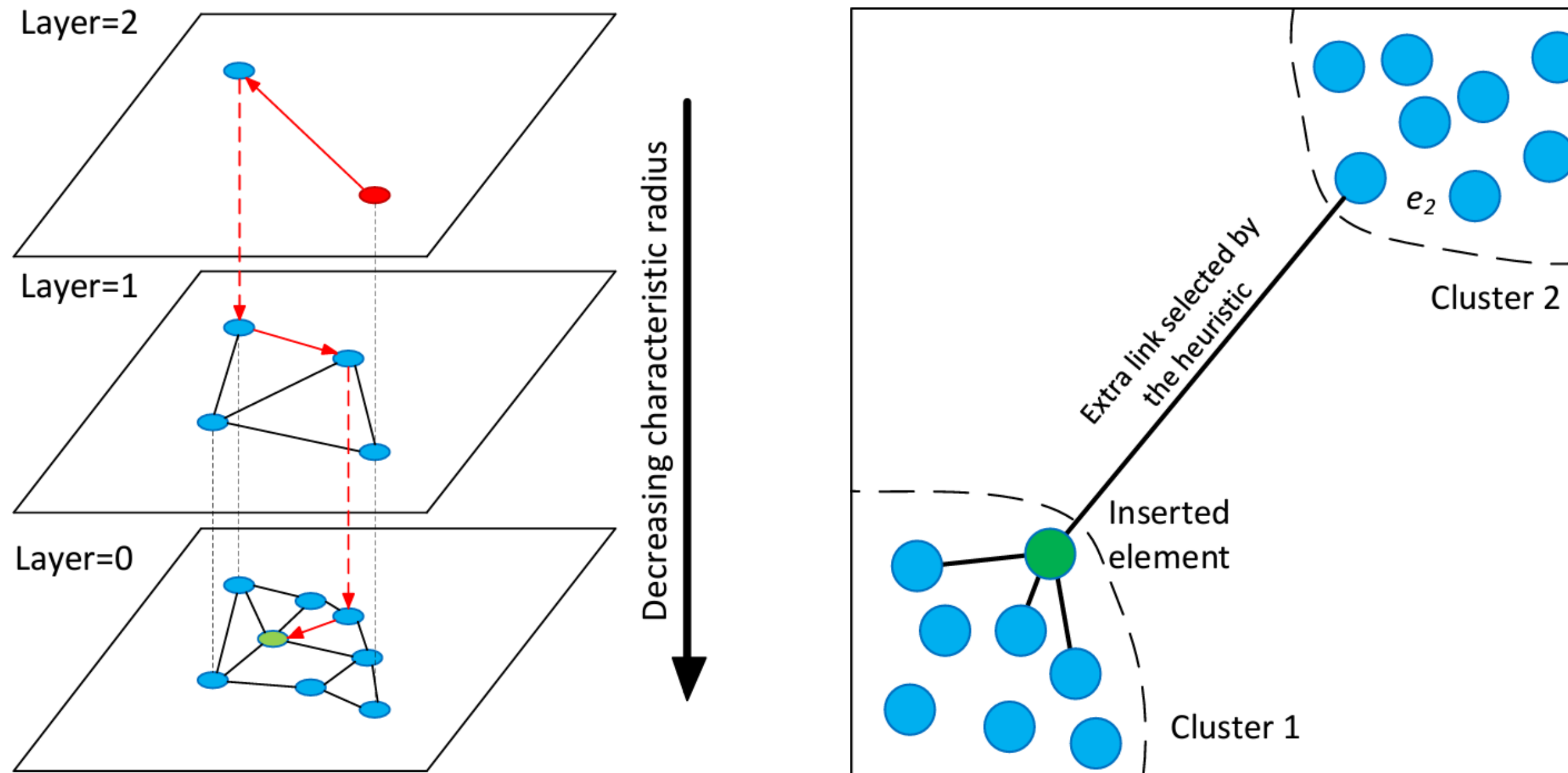


3.

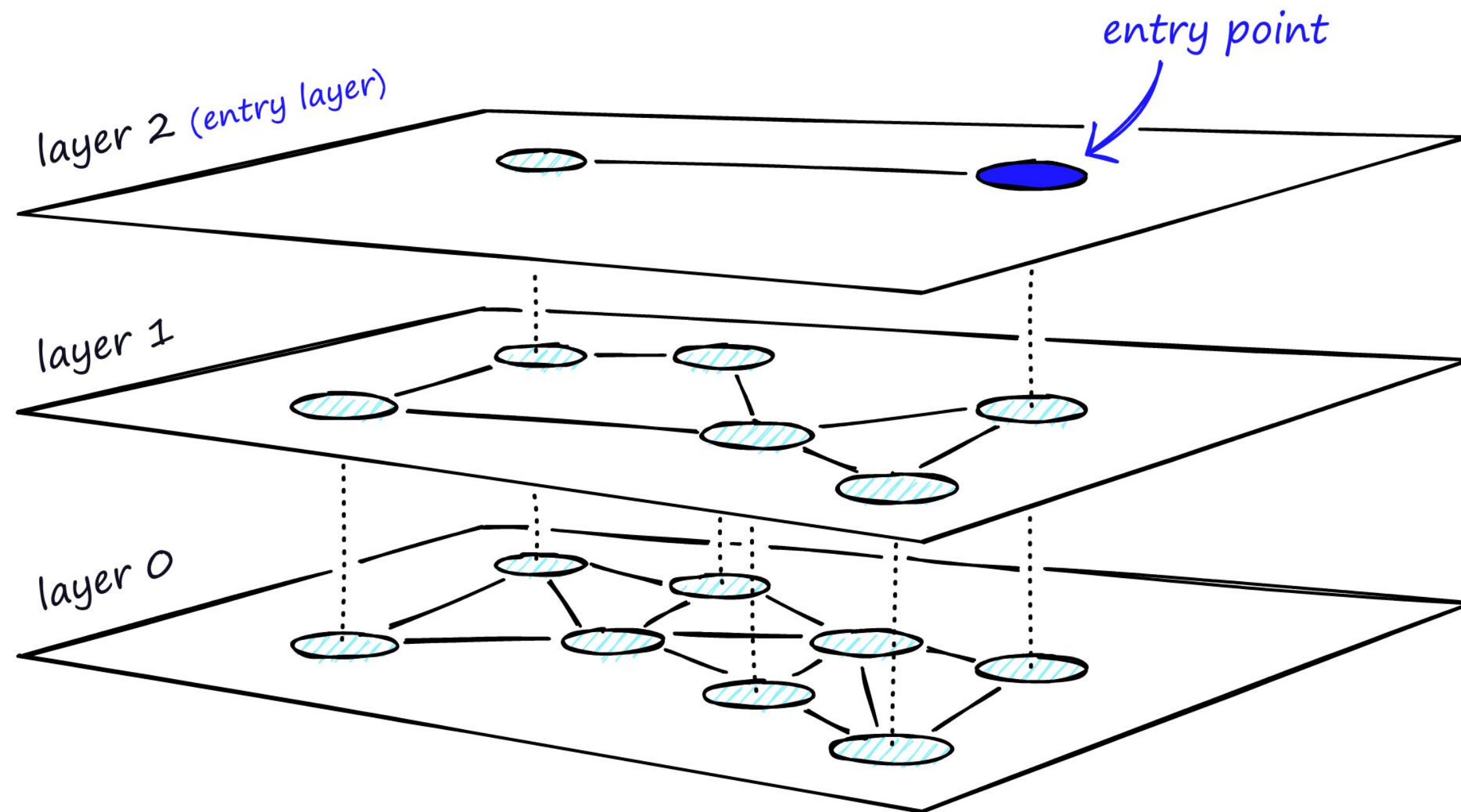
## **Hierarchical Navigable Small Worlds (HNSW)**



# Hierarchical Navigable *Small Worlds* (HNSW)

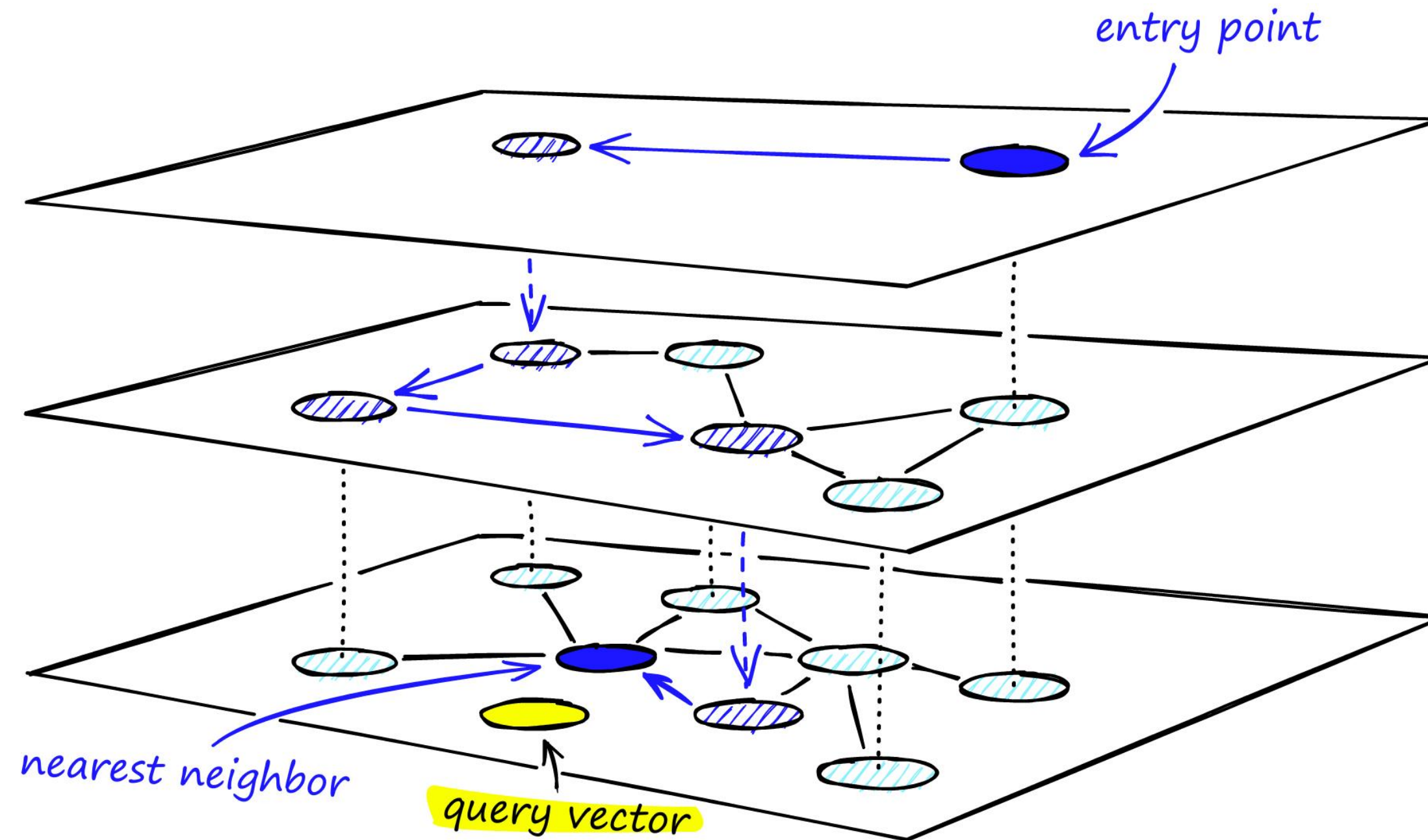


# Hierarchical Navigable *Small Worlds* (HNSW)





# Hierarchical Navigable *Small Worlds* (HNSW)







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