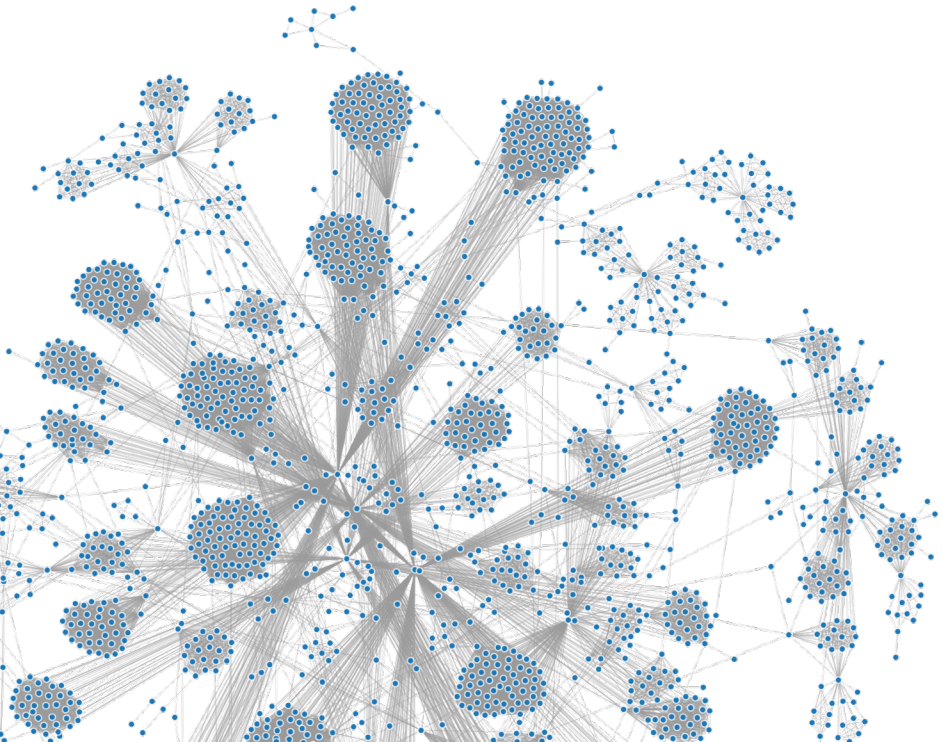
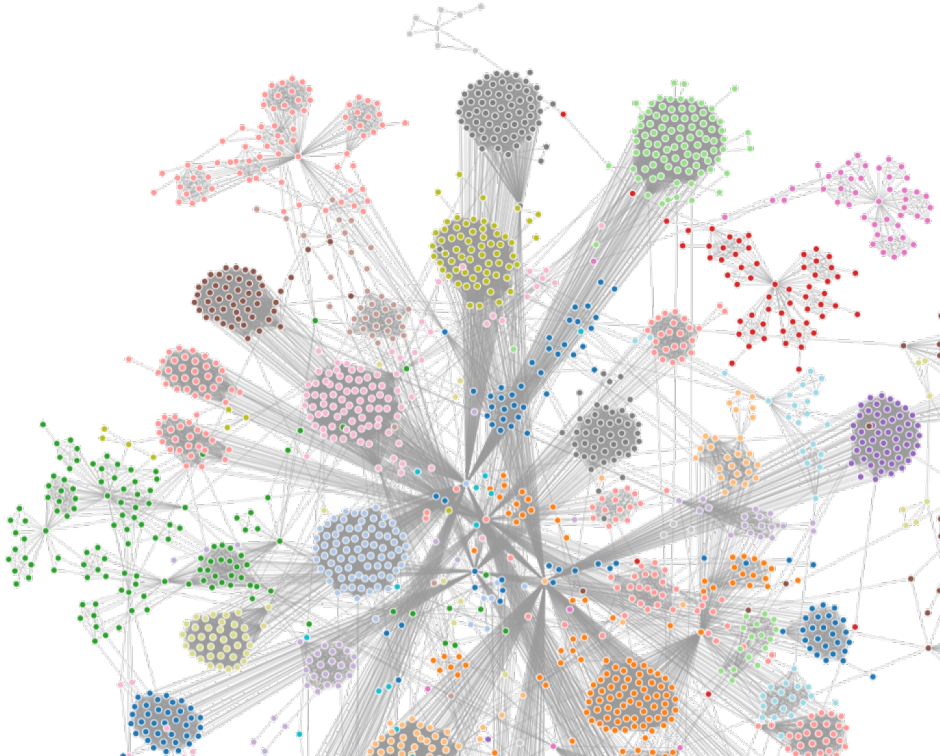
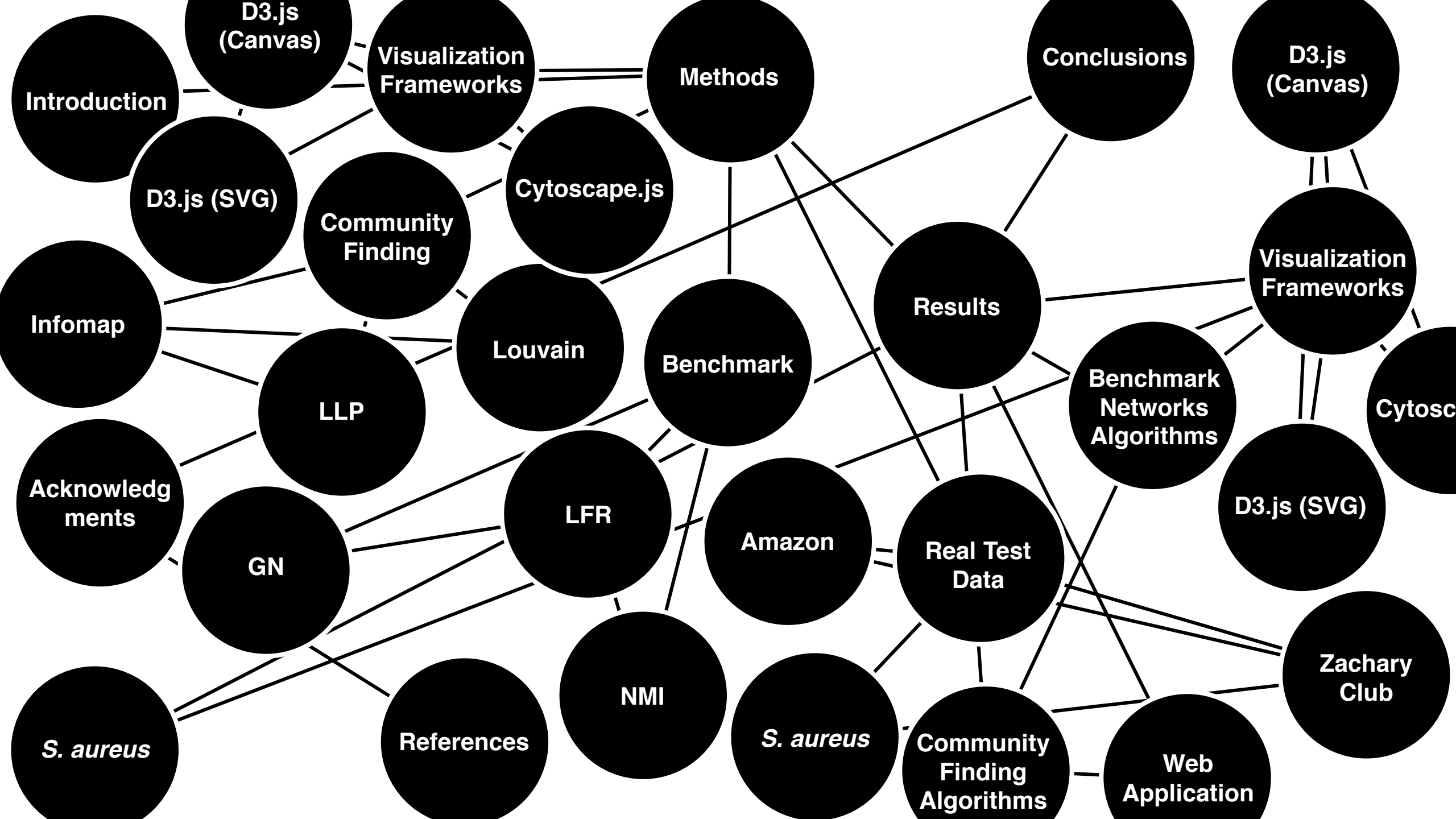
Community Finding with Applications on Phylogenetic Networks

Luís Rita



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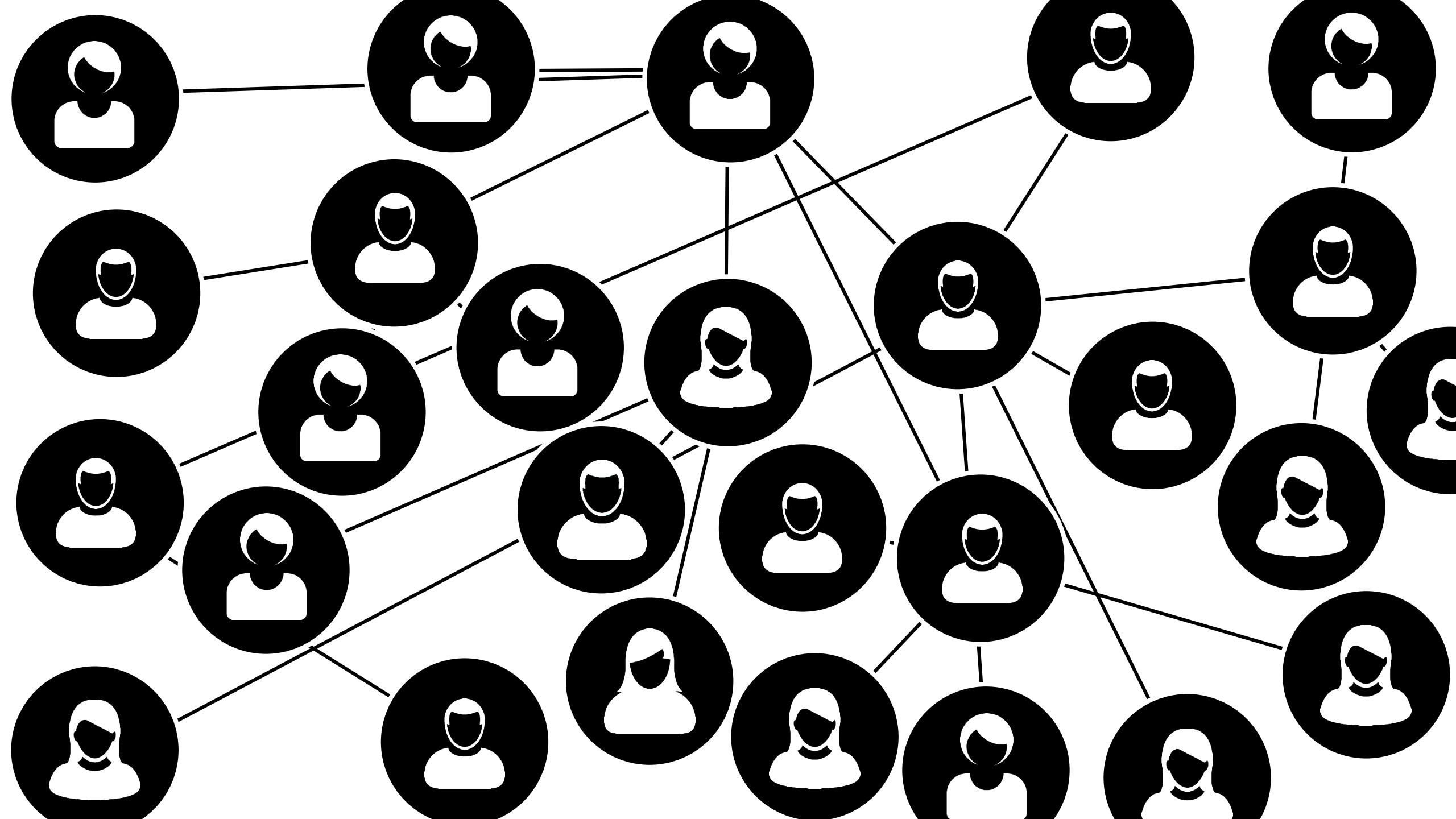

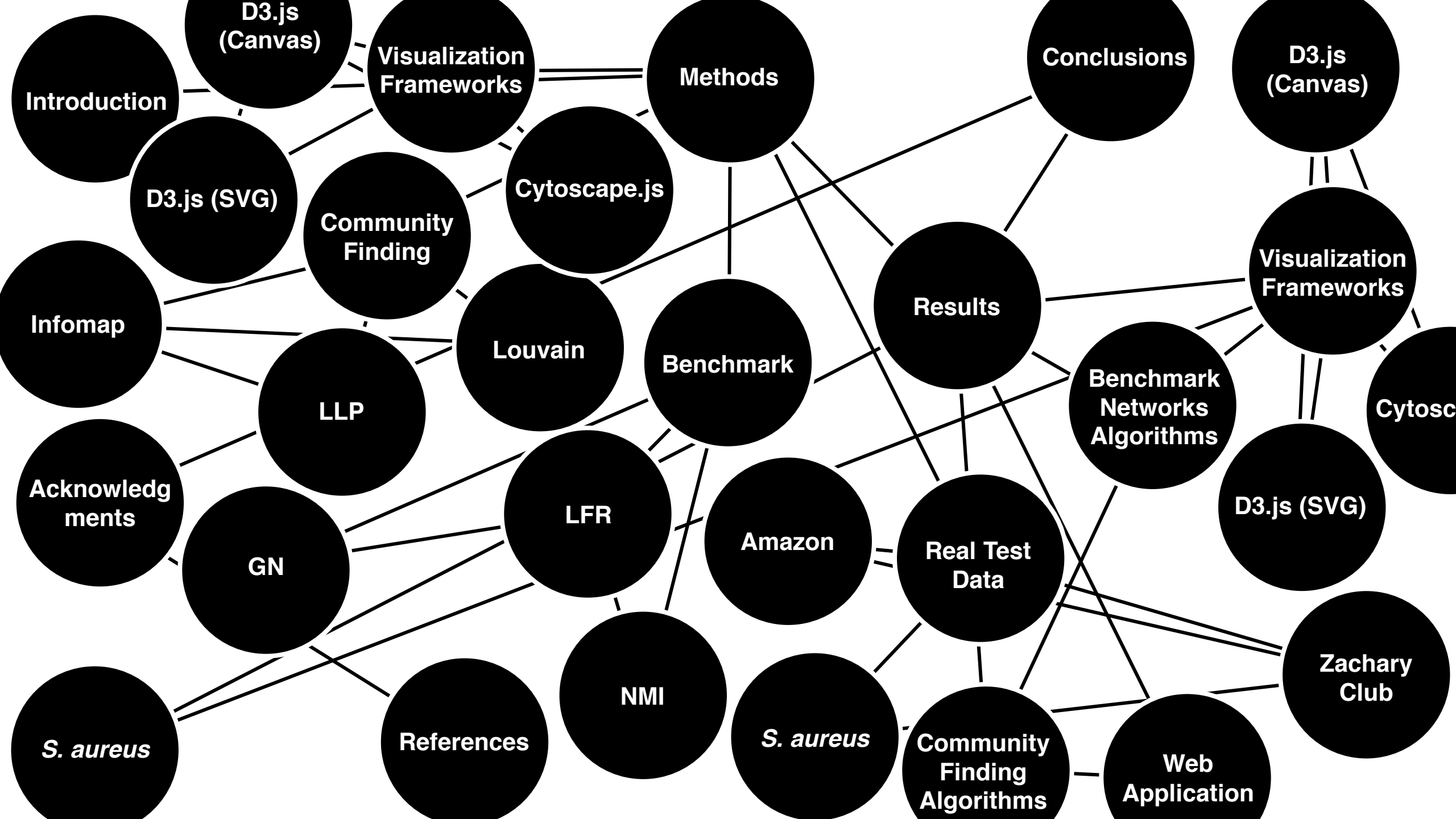
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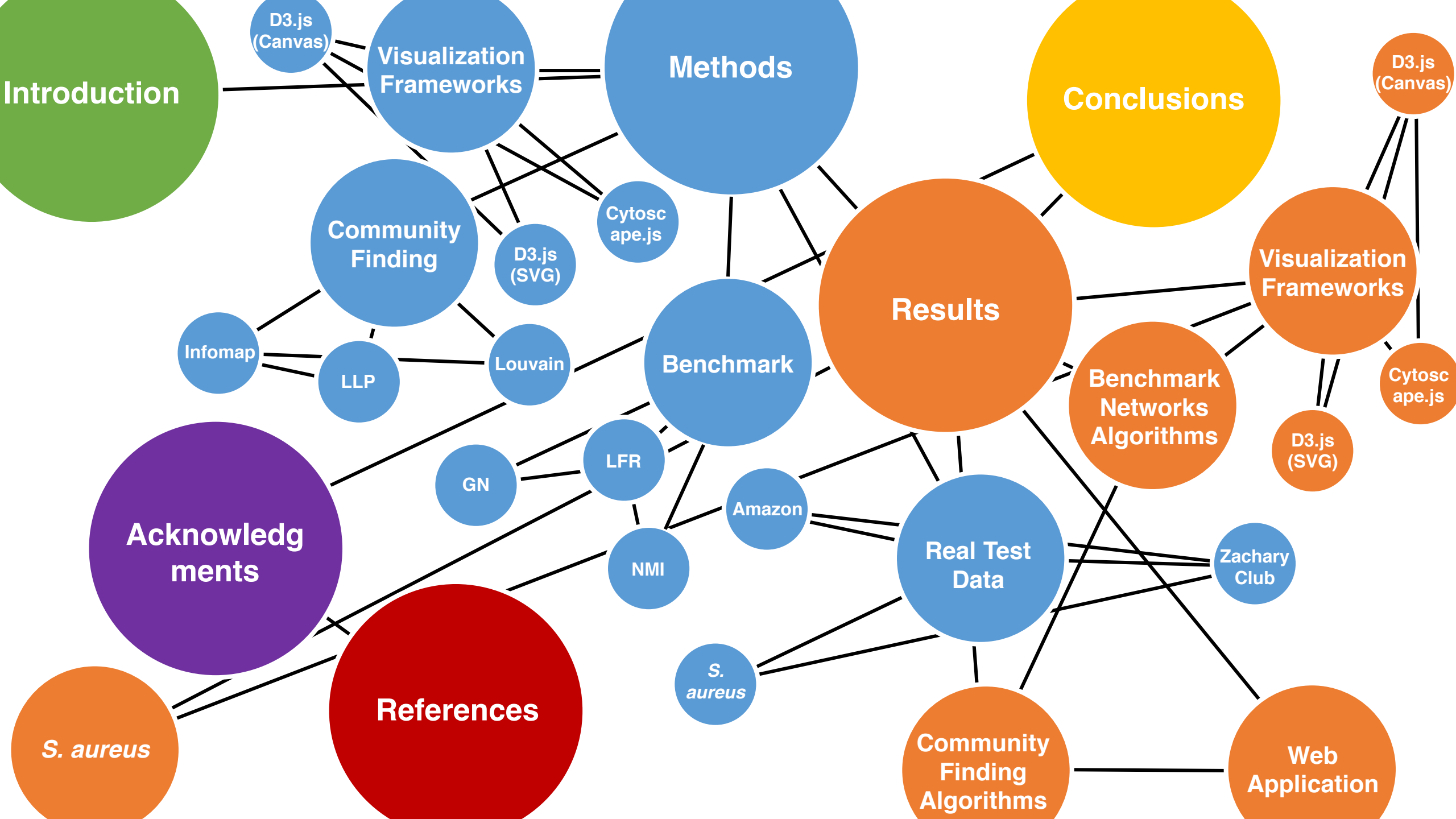
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Introduction

“The world’s most valuable resource is no longer oil, but data.”

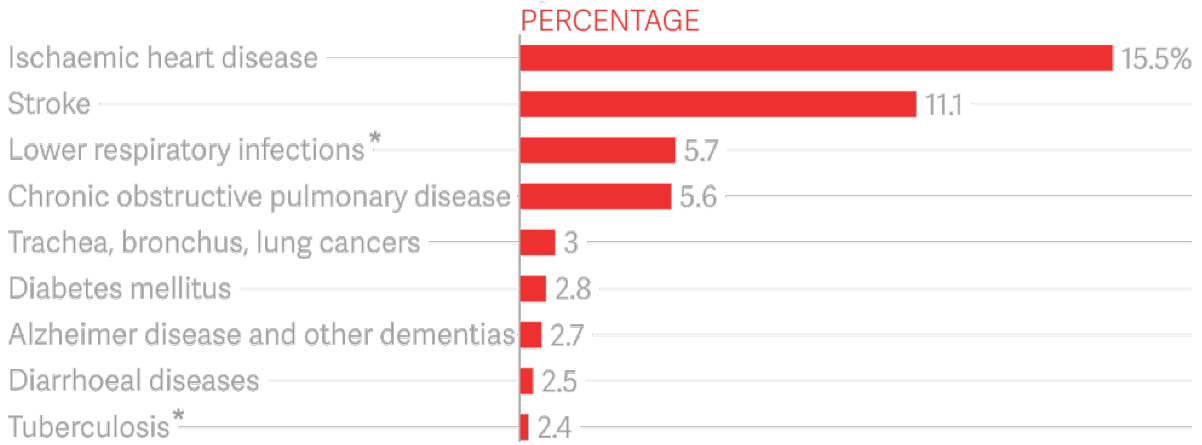
The Economist

“The rapid advances in NGS technologies and capabilities has proven and further promises to be a game changer in diagnostic microbiology (…)”

BDQ Journal (Elsevier)

“Ten threats to global health in 2019 – Antimicrobial Resistance”

World Health Organization



Methods

Community Finding

Louvain

Compute $Mod_{new} = Mod(M)$
repeat
  $Mod = Mod_{new}$
  Randomize the order of vertices.
  for all $i \in V^k$ **do**
    $best_{com} = M_i^k; best_{increase} = 0$
    for all $M' \in C^k$ **do**
      $M_i^k = M_i^k \backslash \{i\}$
      $\Sigma_{tot}{}^{M_i^k} = \sum_{\alpha \in M_i^k} k_\alpha - k_i; \Sigma_{tot}{}^{M'^k_i} = \sum_{\alpha \in M'^k_i} k_\alpha + k_i;$
      $\Sigma_{in} = \Sigma_{tot}{}^{M'^k_i} - \sum k_{i,j}, (i,j) \in E^k, i \in C_i^k \; and \; j \notin C_i^k$
      $k_{i,in} = \sum_{\alpha \in M'^k_i} k_{i,\alpha}$
      If $\delta Mod_{M_i^k \to M'^k_i} > best_{increase}$ then
        $best_{increase} = \delta Mod_{M_i^k \to M'^k_i}$

$$M = \frac{1}{2m} \sum_{i,j} \left(A_{ij} - \frac{k_i k_j}{2m} \right) \delta(c_i, c_j)$$

$$\Delta Mm = k_{i,in} - \frac{\sum_{tot} k_i}{2m}$$

Infomap

Compute $L_{new} = L(M)$
repeat
  $L = L_{new}$
  Randomize the order of vertices.
  for all $u \in V^k$ do
    if $M'^k_u = argmin \left(\delta L_{M_u^k \to M'^k_u} \right) < 0$ then
      $M_u^k = M_u^k \backslash \{u\}; M'^k_u = M'^k_u \cup \{u\}$
      $p^{M_u^k} = \sum_{\alpha \in M_u^k} p_\alpha - p_u; p^{M'^k_u} = \sum_{\alpha \in M'^k_u} p_\alpha + p_u$
      update $q^{M_u^k}$; update $q^{M'^k_u}$
    end if
  end for
  Compute $L_{new} = L(M)$
until No vertex movement or $L - L_{new} < \theta$
Compute $L_{new} = L(M)$

$$L(M) = \left(\sum_{m \in M} q_m \right) log \left(\sum_{m \in M} q_m \right) - 2 \sum_{m \in M} q_m \, log(q_m) - \sum_{\alpha \in V} p_\alpha \, log(p_\alpha) + \sum_{m \in M} \left(q_m + \sum_{\alpha \in m} p_\alpha \right) log \left(q_m + \sum_{\alpha \in m} p_\alpha \right)$$

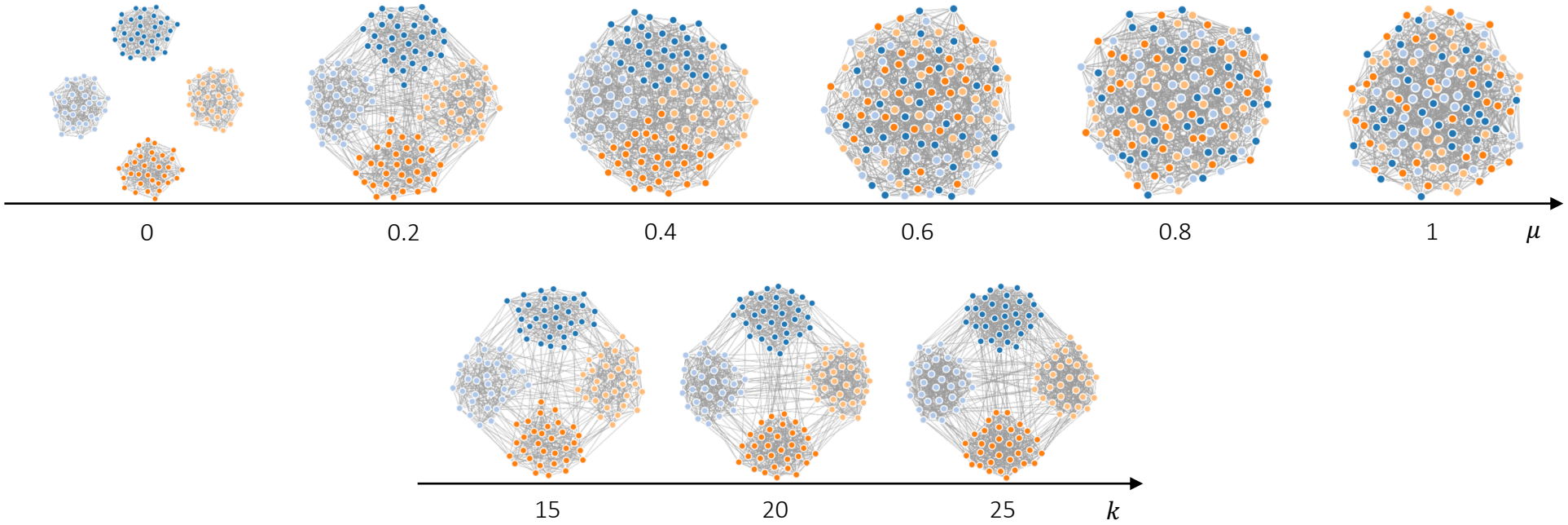
Layered Label Propagation

$k = 0$
for all $i \in V^0$ **do**
  $M_i^0 = \{i\}$
end for
repeat
  Randomize the order of vertices.
  for all $u \in V^k$ **do**
    for all $i \in labels(u)$ **do**
      If $k_i(u) - \gamma(v_i(u) - k_i(u)) > k_{i-1}(u) - \gamma(v_{i-1}(u) - k_{i-1}(u))$ then
        $M_u^k = M_u^k \backslash \{u\}; M'^k_u = M'^k_u \cup \{u\}$
      end if
    end for
  end for
$k = k + 1$
until No vertex movement or $k < max_{iteration}$

$$k_i - \gamma(v_i - k_i)$$

Methods

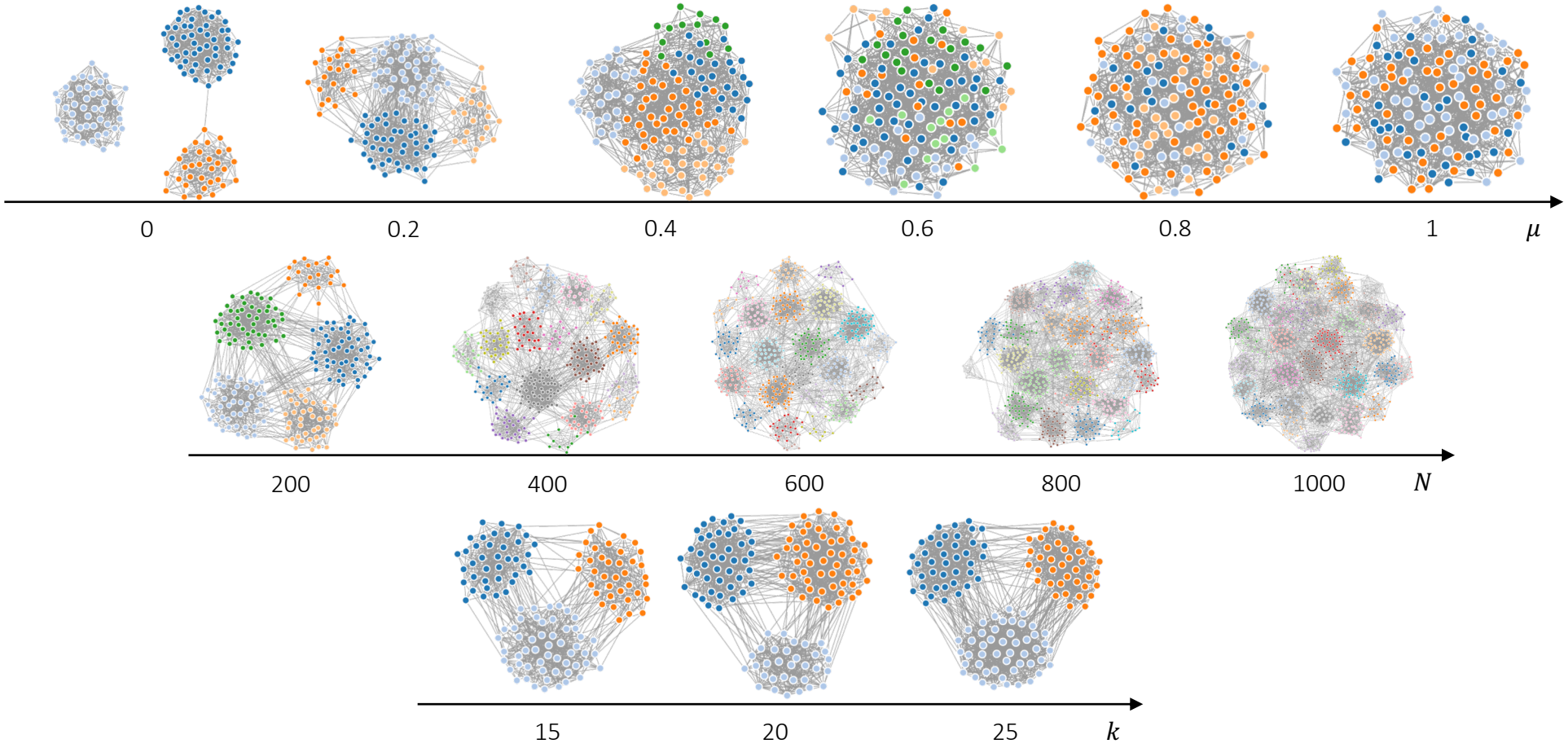
Benchmark Networks



Girvan - Newman

Methods

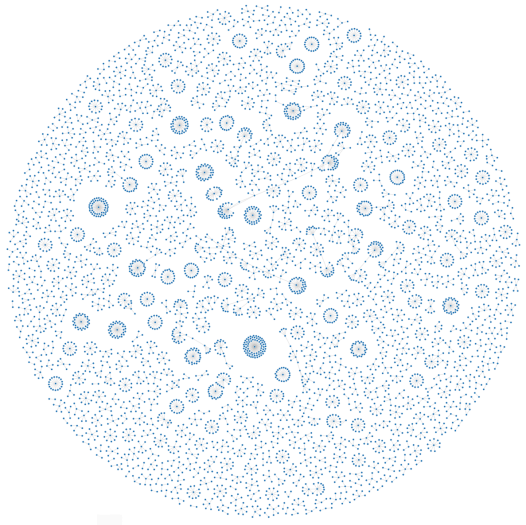
Benchmark Networks



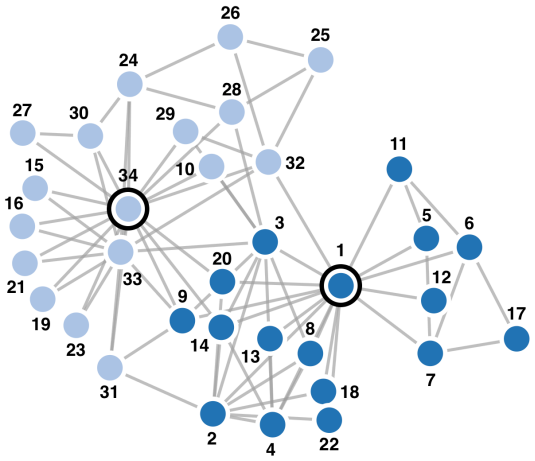
Lancichinetti - Fortunato - Radicchi

Methods

Real Test Data



Amazon

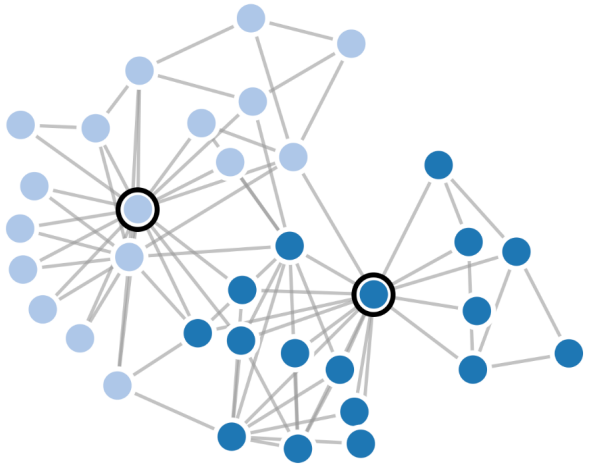


Zachary's Karate Club

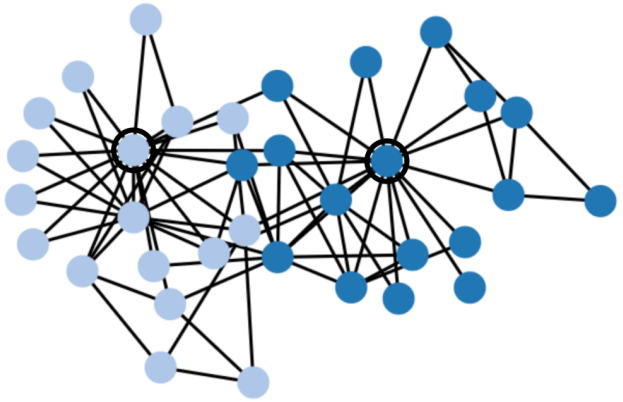
Staphylococcus aureus
MLST SLV Network

Methods

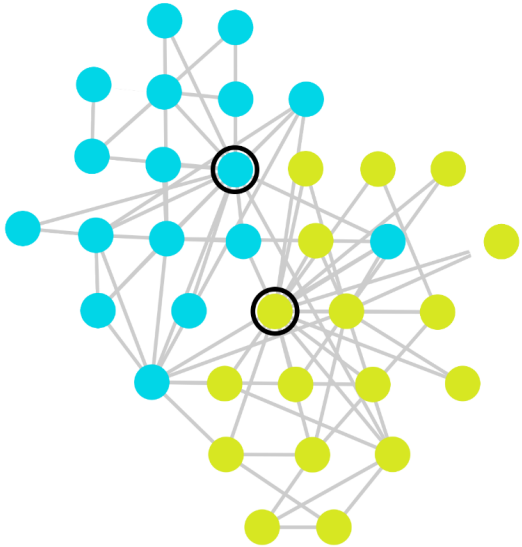
Visualization Frameworks



D3.js & SVG



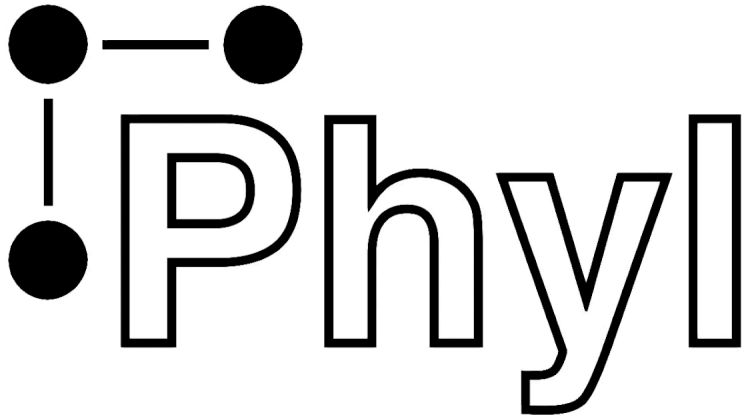
D3.js & Canvas



Cytoscape.js

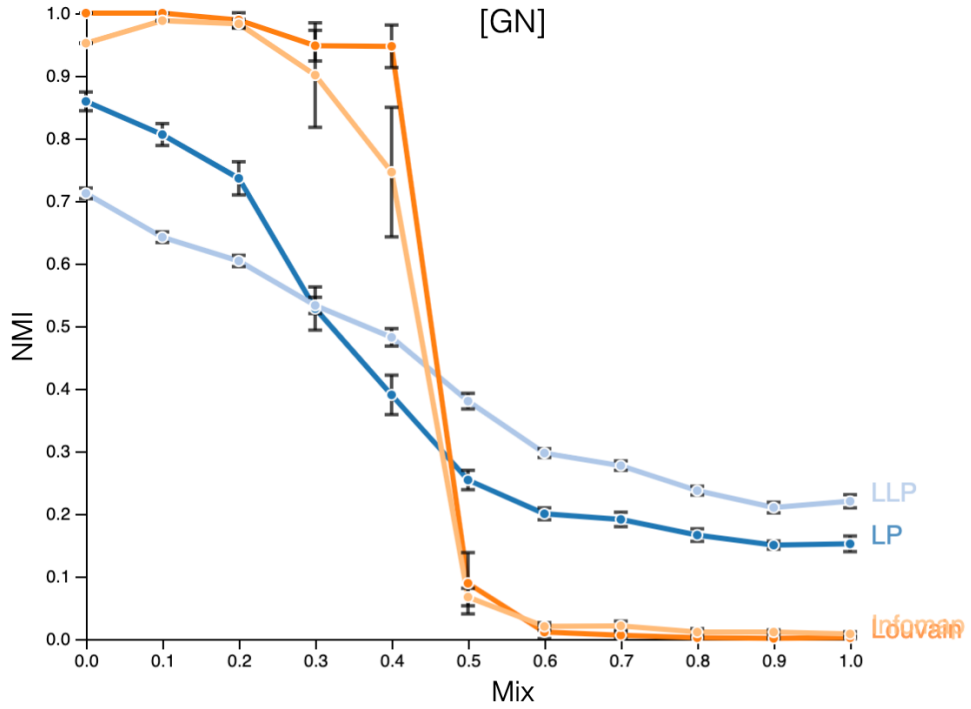
Results

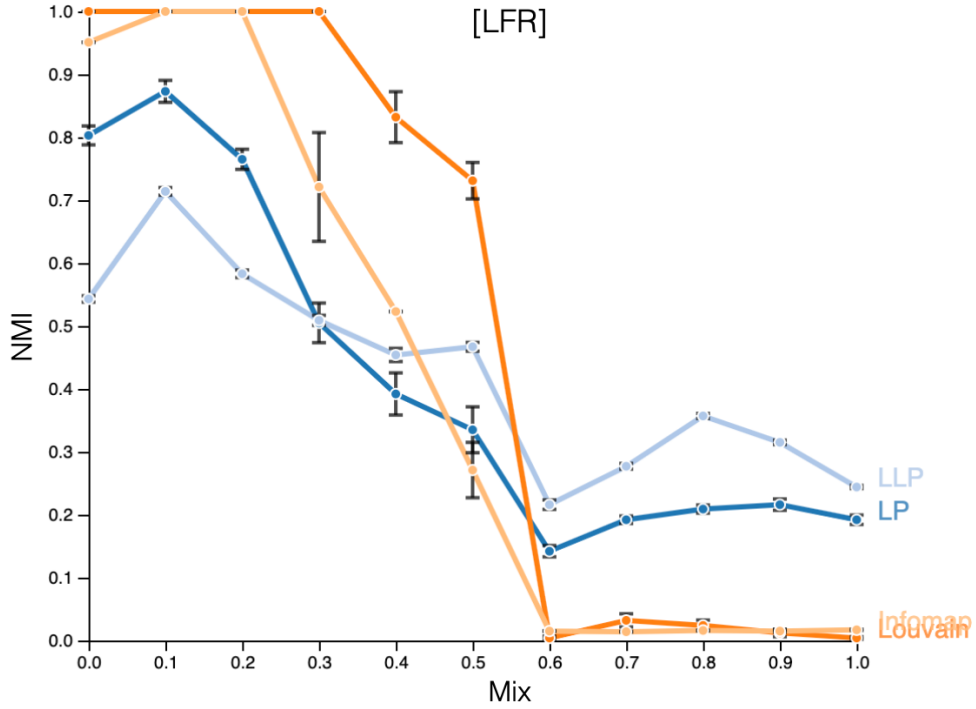
Web Application



Results

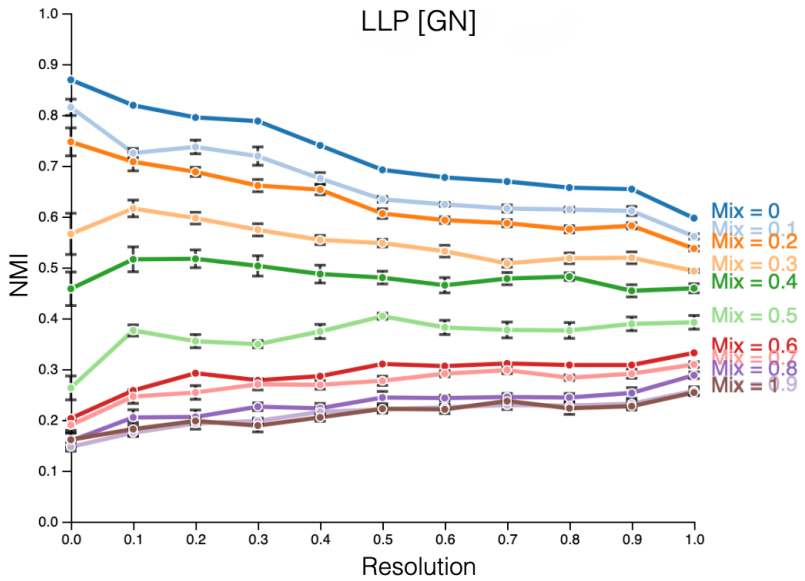
Community Finding Algorithms



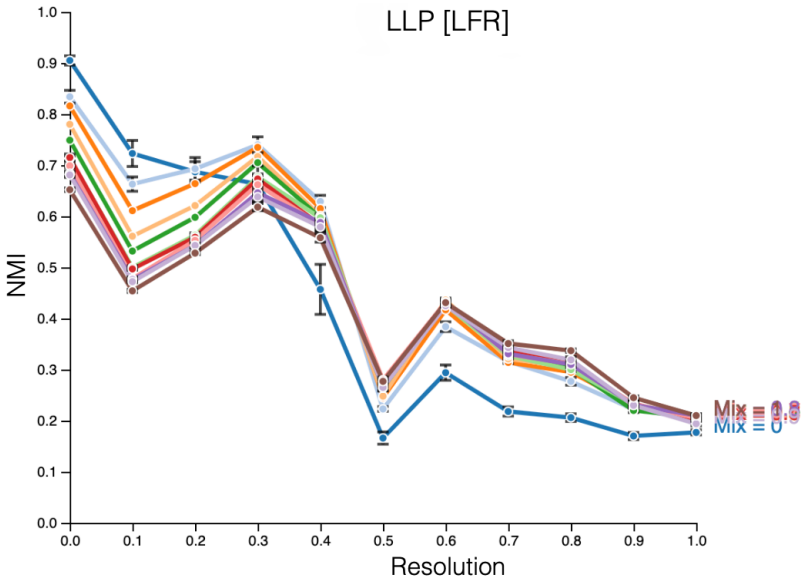


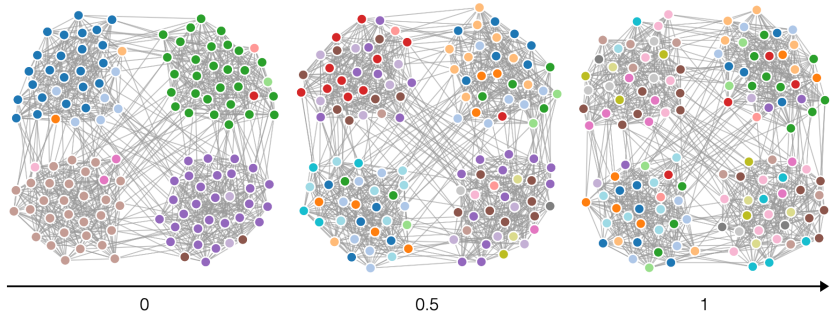
Results

Community Finding Algorithms



$$k_i - \gamma(v_i - k_i)$$





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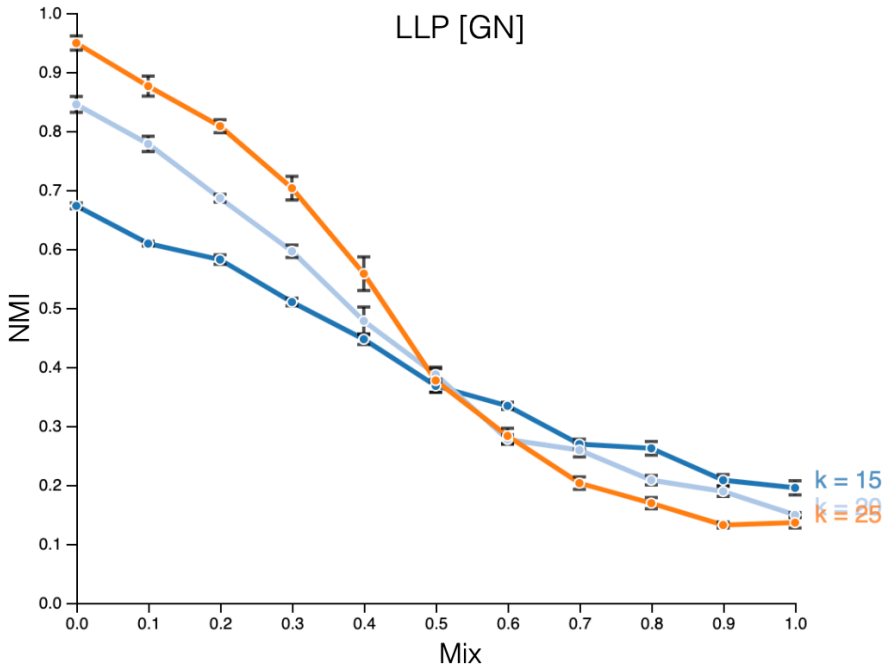
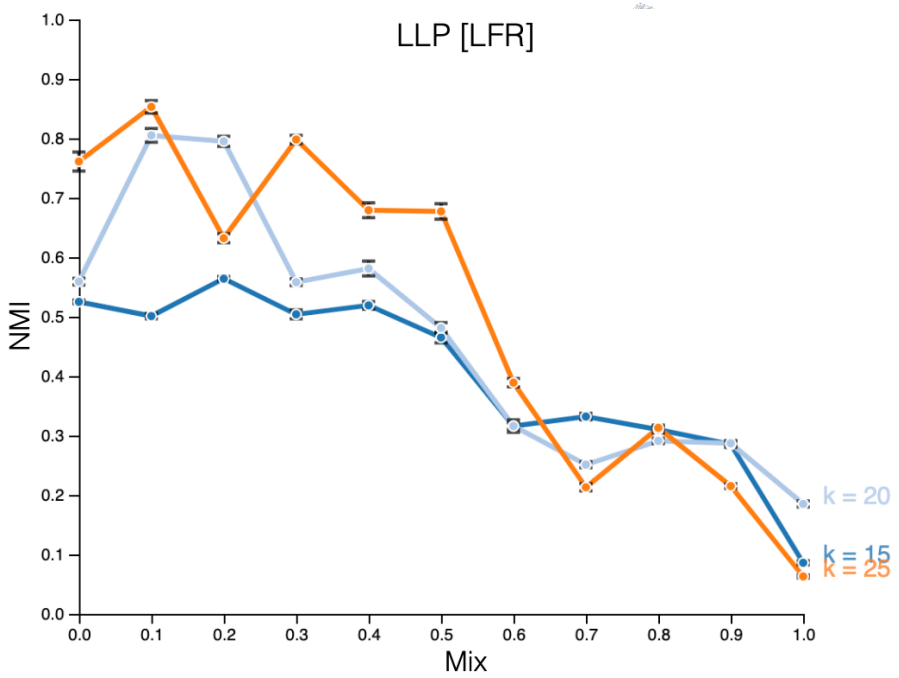
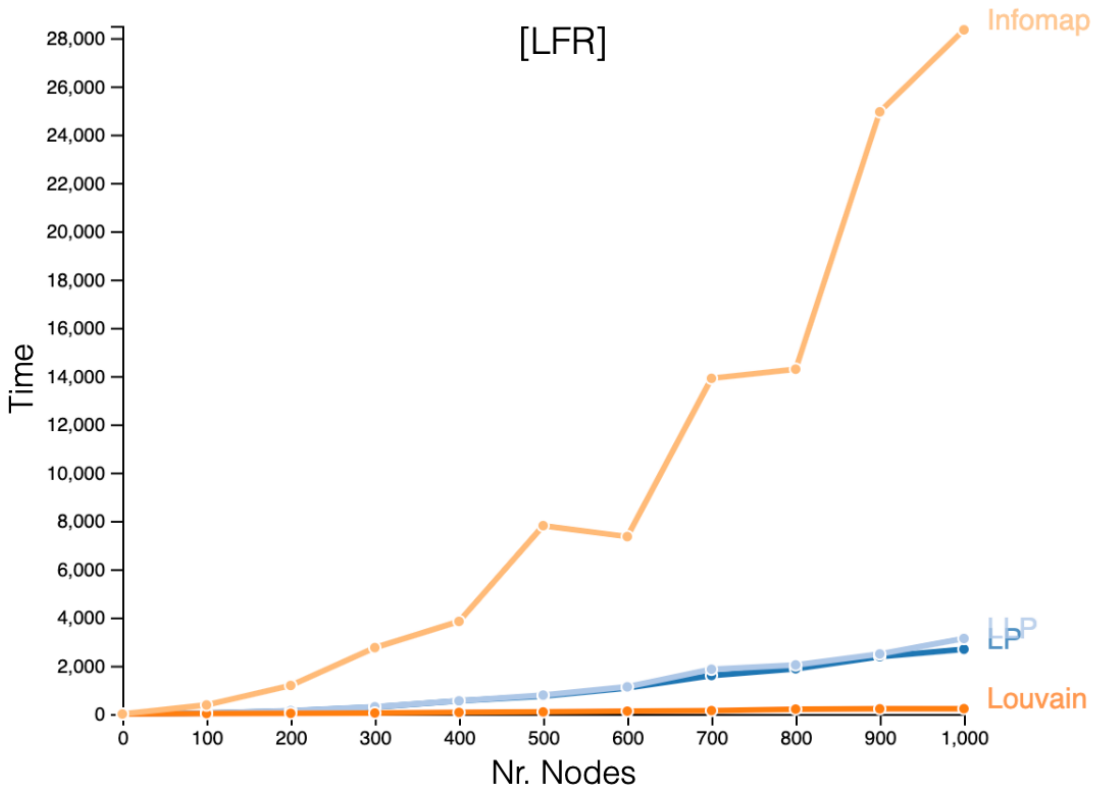




Results

Community Finding Algorithms



Algorithm	Time Complexity
Louvain	$O(L)$
Infomap	$O(NlogN)$
LP	$O(L)$
LLP	$O(L)$

$$\Delta Mm = k_{i,in} - \frac{\sum_{tot} k_i}{2m}$$

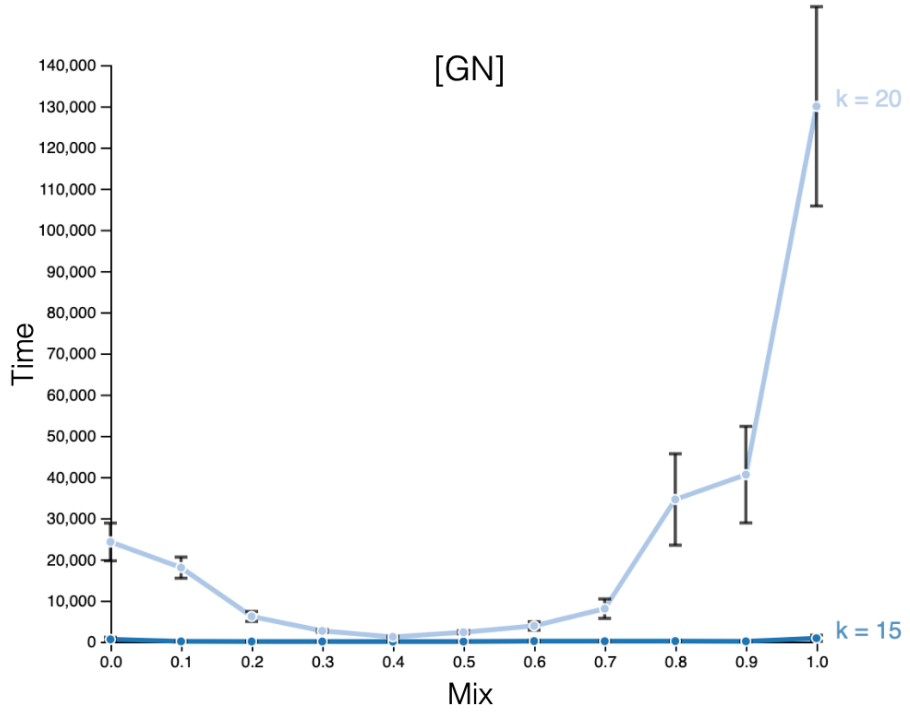
$$= \left(\sum_{m \in M} q_m\right) log\left(\sum_{m \in M} q_m\right) - 2\sum_{m \in M} q_m \, log(q_m) - \sum_{\alpha \in V} p_\alpha \, log(p_\alpha) + \sum_{m \in M}\left(q_m + \sum_{\alpha \in m} p_\alpha\right) log\left(q_m + \sum_{\alpha \in m} p_\alpha\right)$$

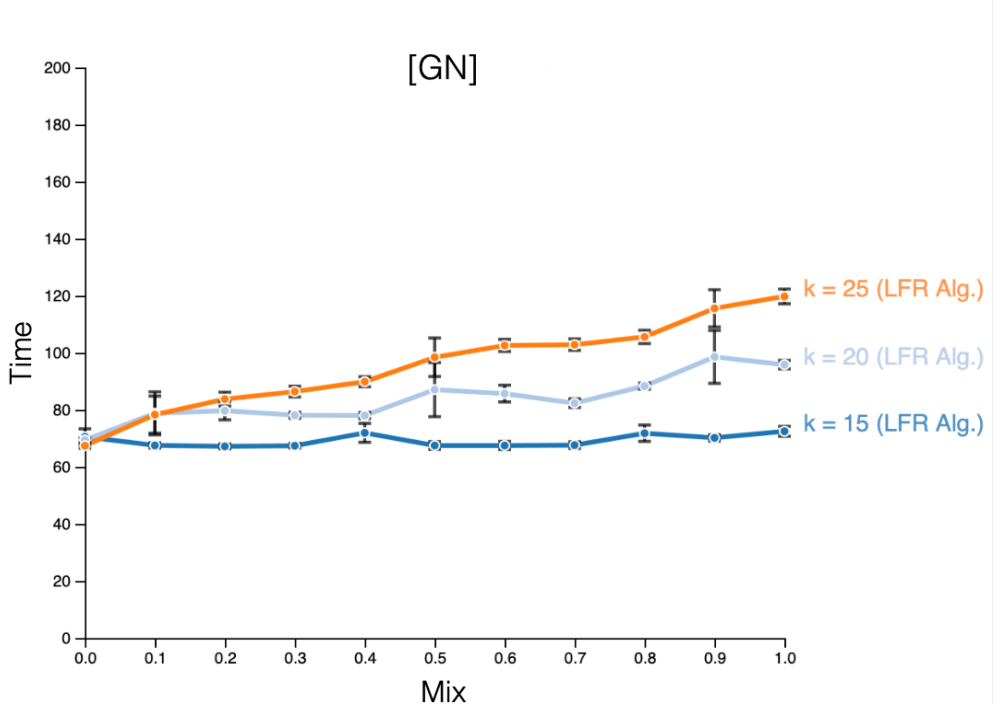
$$k_i - \gamma(v_i - k_i)$$

$L(M)$

Results

Benchmark Networks Algorithms





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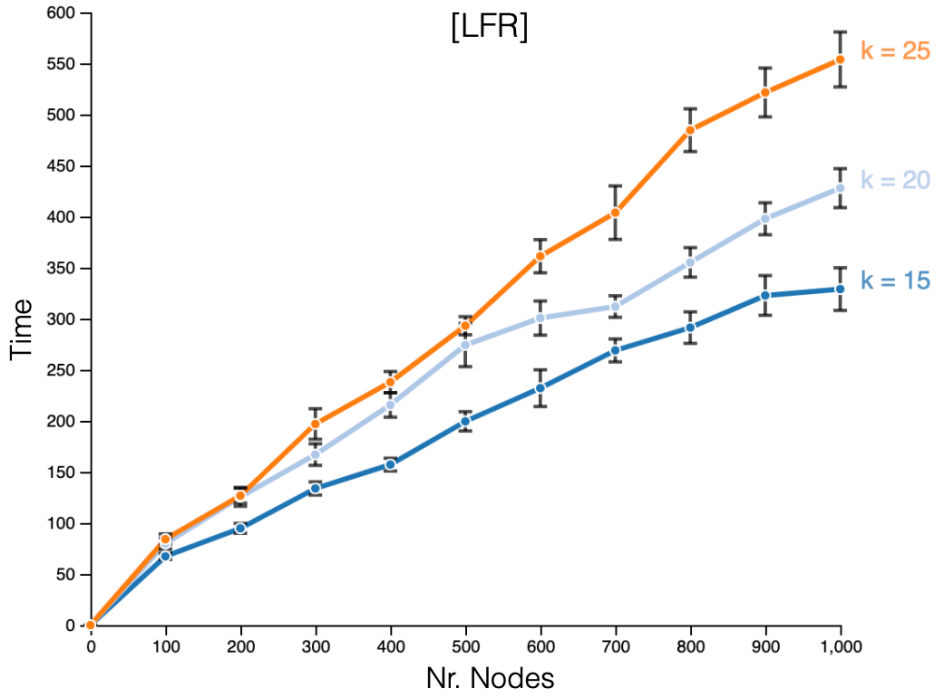
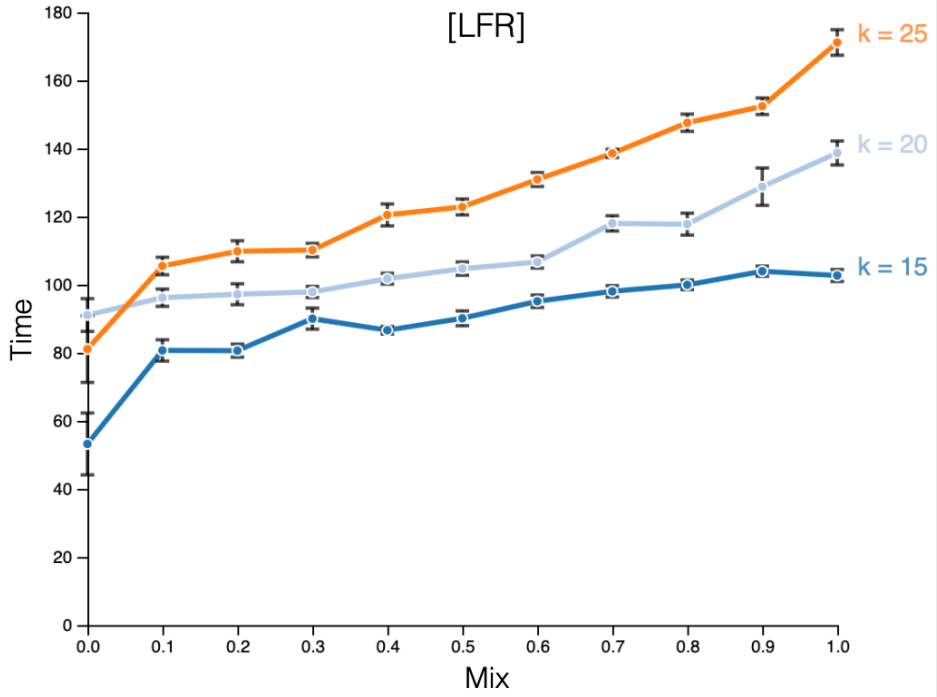
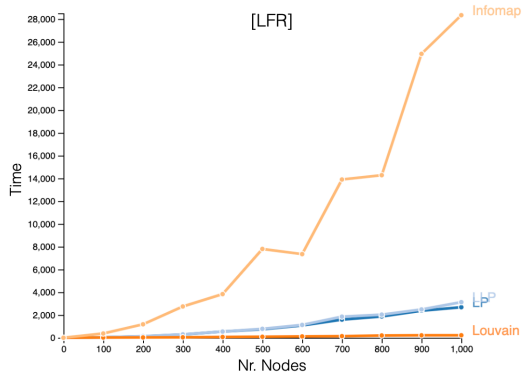


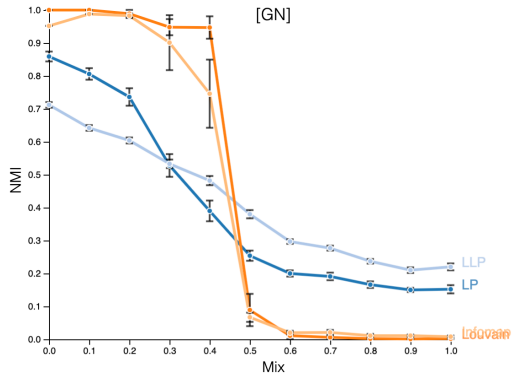


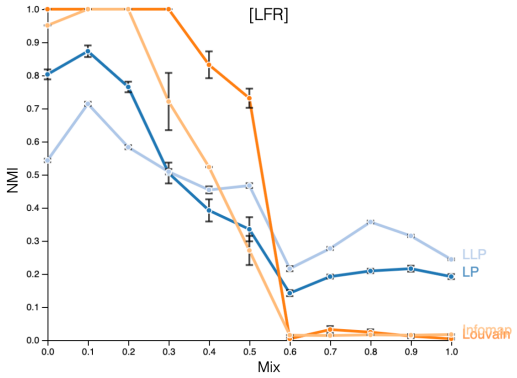
Results

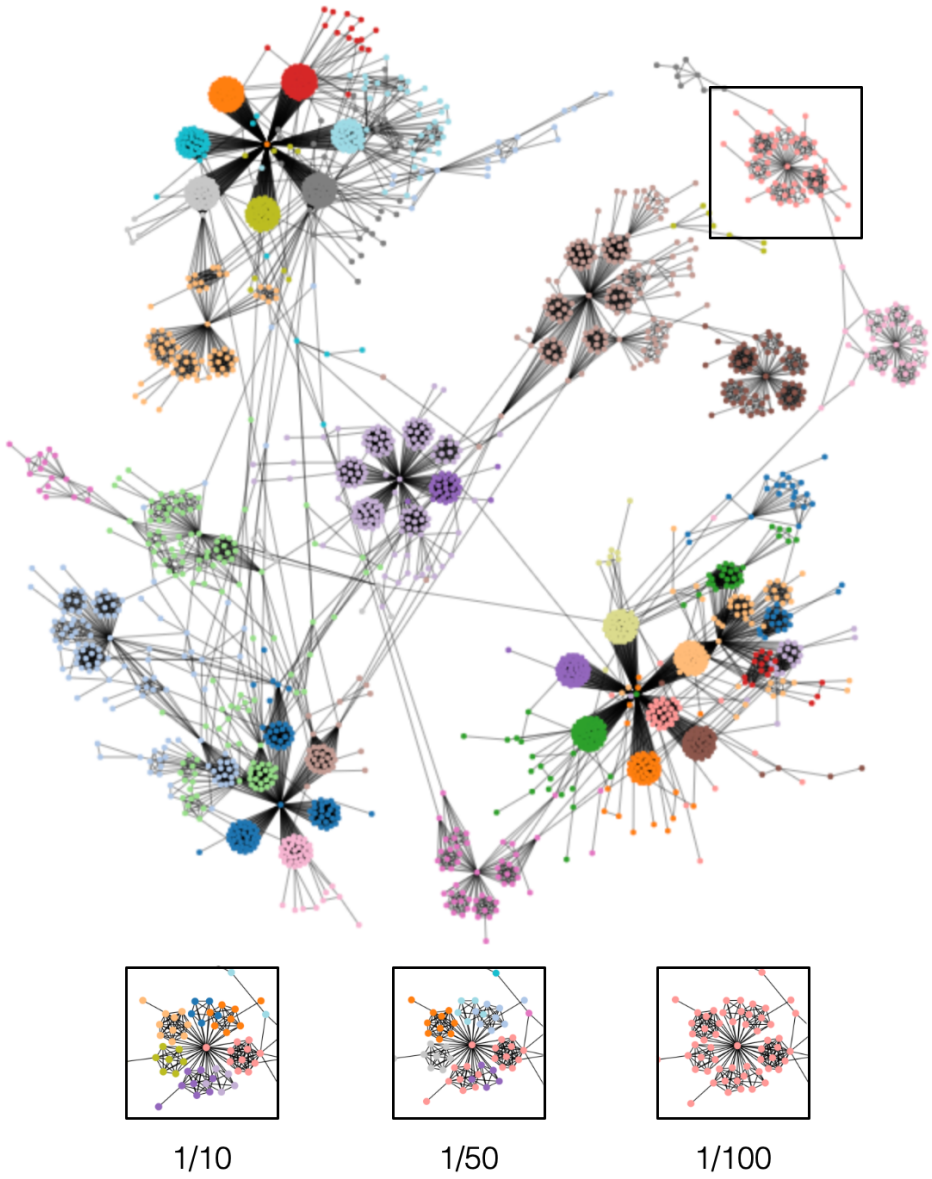
Staphylococcus aureus



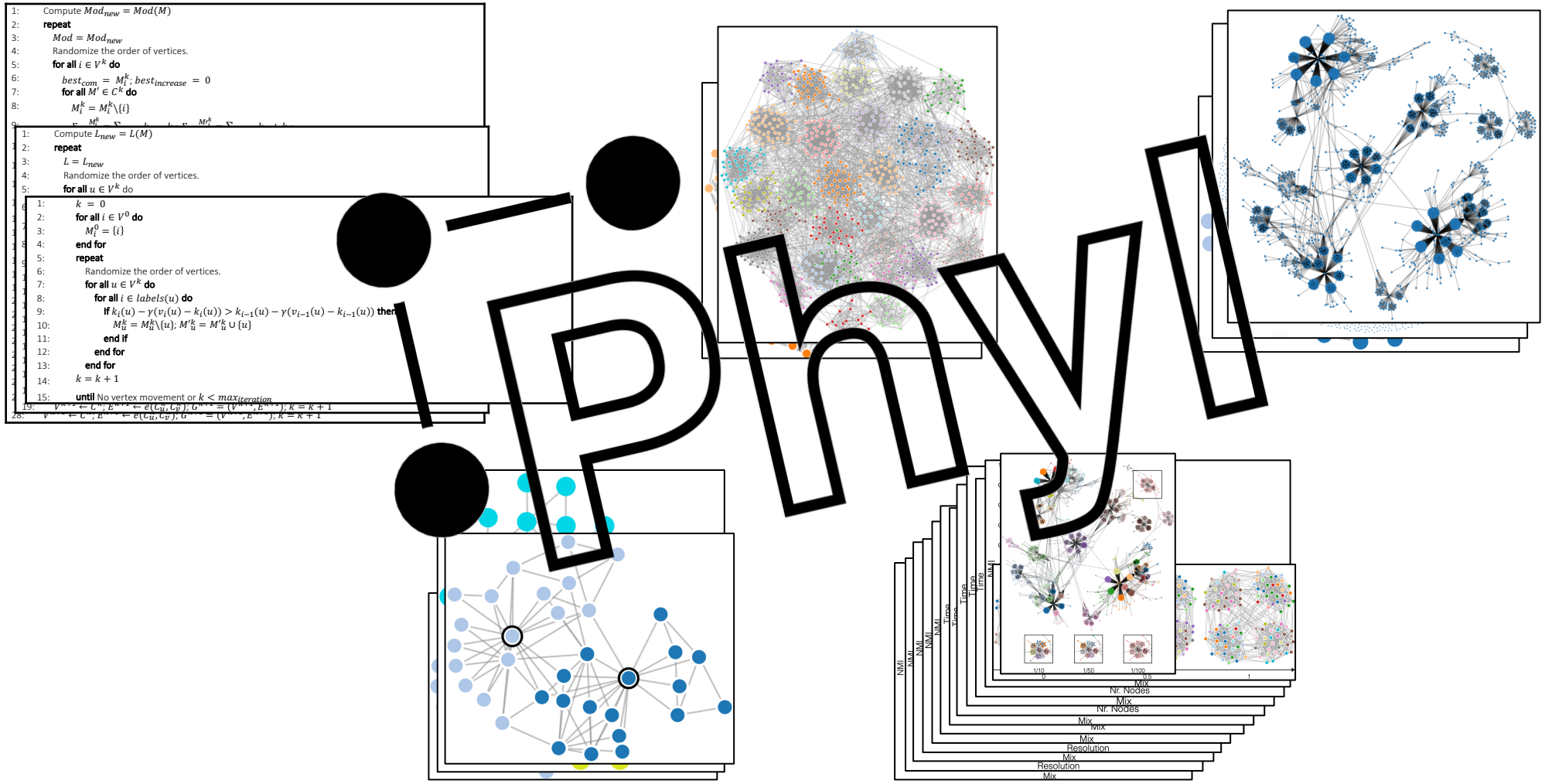
Louvain & D3.js (Canvas)



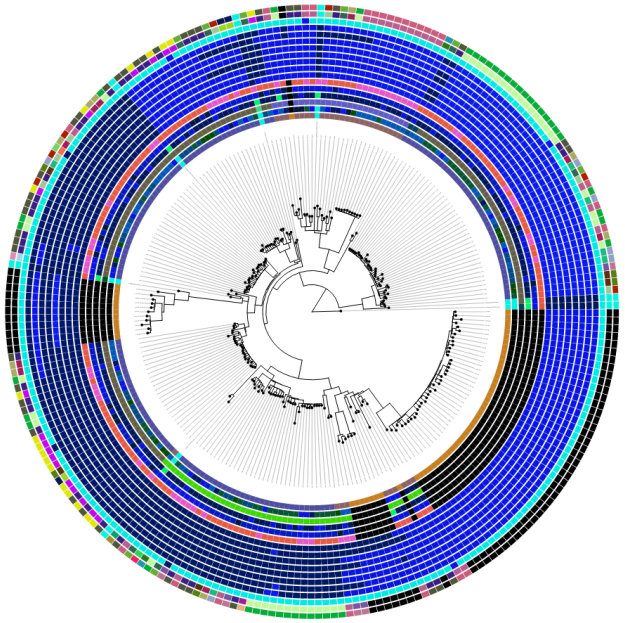


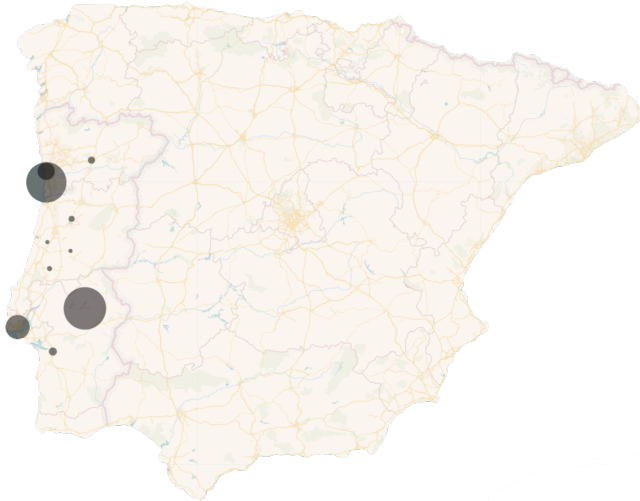


Conclusions



Future Work





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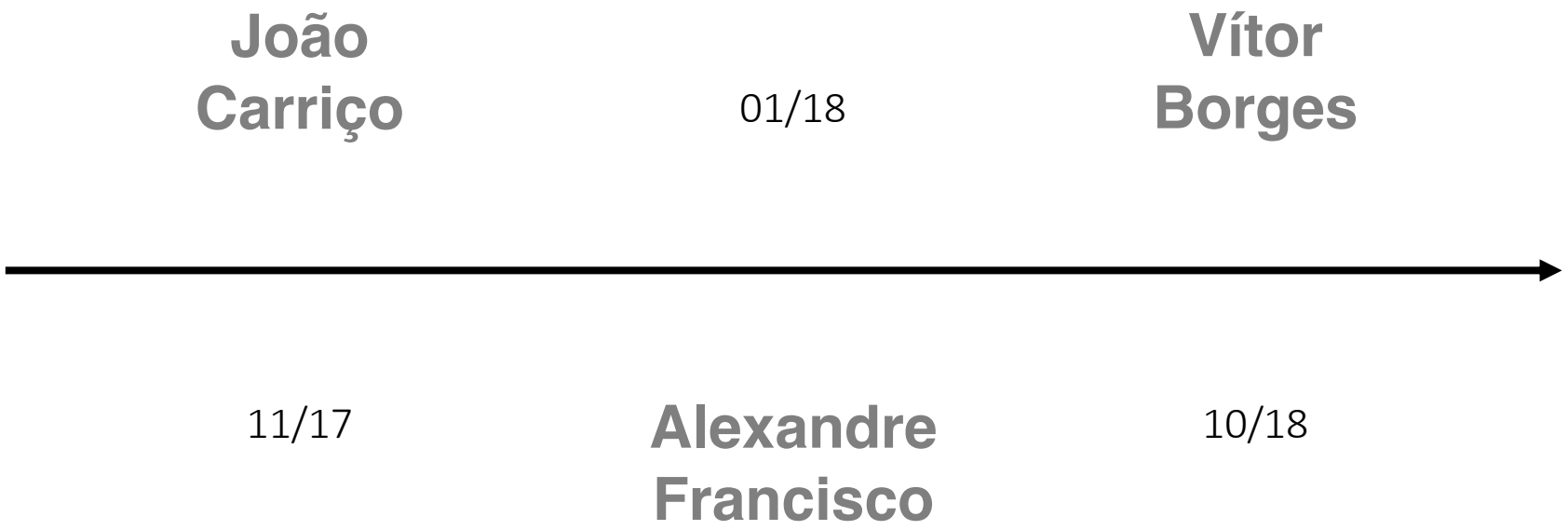

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