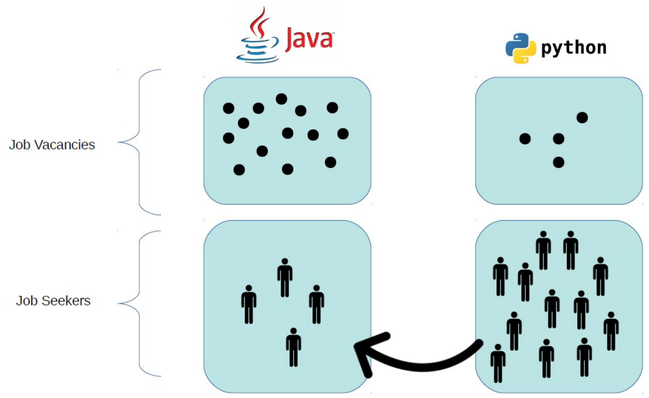
Quantifying and Reducing Imbalance in Networks

Yoosof Mashayekhi, Bo Kang, Jefrey Lijffijt, Tijl De Bie

(firstname.lastname@ugent.be)

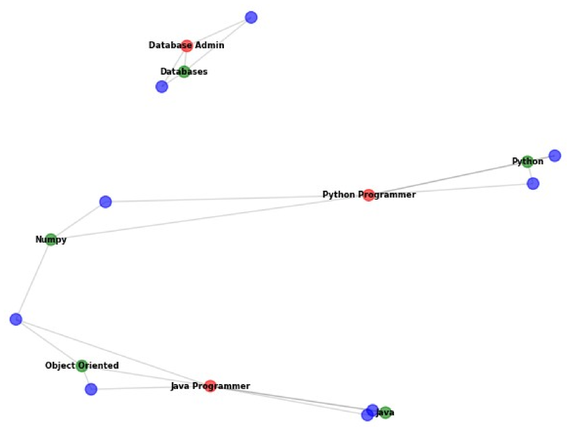
Motivation

Imbalance in a Job Market



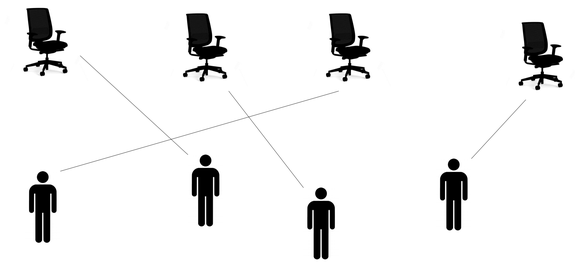
Our Approach

Job Market Network Embedding



Imbalance Quantification

Minimum cost of matching two sets of nodes (Job seekers and vacancies)



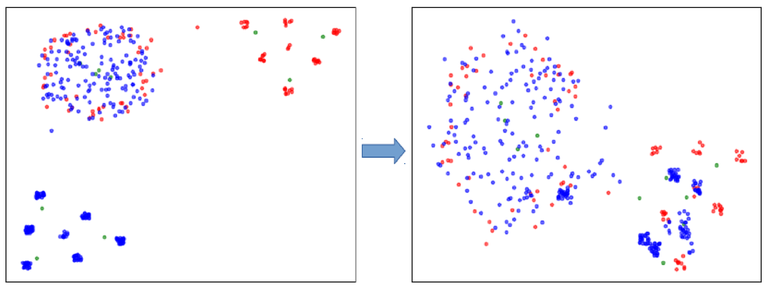
$$C = \sum_{i \in S} \sum_{j \in T} f_{ij} d_{ij},$$

$$\text{s.t.} \quad f_{ij} \geq 0 \quad \forall (i,j) \in S \times T,$$

$$\sum_{j \in T} f_{ij} = w_i \quad \forall i \in S, \quad \sum_{i \in S} f_{ij} = w_j \quad \forall j \in T$$

Imbalance Reduction by Adding Links

Add K links to the network to reduce the imbalance optimally



Move job seekers to areas with more vacancies and fewer job seekers with a greedy algorithm

$$\delta_{S,T}(\boldsymbol{x}; X) = \ln\left(\frac{p_T(\boldsymbol{x}; X)}{p_S(\boldsymbol{x}; X)}\right)$$

Link Utility

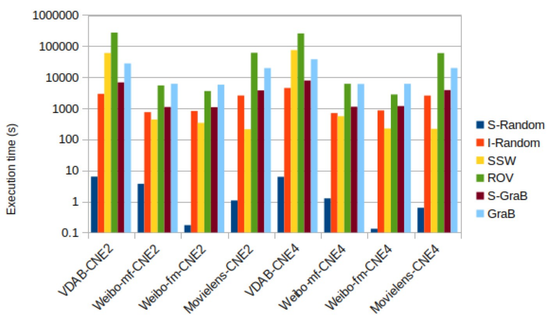
$$\frac{\partial \delta_{S,T}(\boldsymbol{x}; X)}{\partial a_{ij}} = \nabla_{\boldsymbol{x}} \delta_{S,T}(\boldsymbol{x}; X)^T \frac{\partial \boldsymbol{x}(\boldsymbol{A})}{\partial a_{ij}}$$

$$+ \sum_{r \in S} \nabla_{\boldsymbol{x}_r} \delta_{S,T}(\boldsymbol{x}; X)^T \frac{\partial \boldsymbol{x}_r(\boldsymbol{A})}{\partial a_{ij}} + \sum_{r \in T} \nabla_{\boldsymbol{x}_r} \delta_{S,T}(\boldsymbol{x}; X)^T \frac{\partial \boldsymbol{x}_r(\boldsymbol{A})}{\partial a_{ij}}$$

Evaluation

Network Imbalance after adding 100 links to each network. Best performance per dataset is highlighted in bold.

Dataset	Main Graph	S-Random	I-Random	SSW	ROV	S-GraB	GraB
VDAB-CNE2	0.2357	0.2335	0.2286	0.2351	0.2362	0.2254	**0.2245**
Weibo-mf-CNE2	0.5729	0.5650	0.5479	0.5361	0.56891	0.5191	**0.4955**
Weibo-fm-CNE2	0.5724	0.5750	0.5419	0.6763	0.5739	0.4917	**0.4425**
Movielens-CNE2	0.4667	0.4653	0.4654	0.4501	0.4652	0.4458	**0.4400**
VDAB-CNE4	0.4211	0.4206	0.4164	0.4195	0.4213	0.4170	**0.4137**
Weibo-mf-CNE4	0.6432	0.6423	0.6245	0.6252	0.6506	0.6269	**0.6049**
Weibo-fm-CNE4	0.6536	0.6486	0.6290	0.7175	0.6446	0.6235	**0.5895**
Movielens-CNE4	0.6031	0.5927	0.5990	0.5856	0.6002	0.5748	**0.5686**



Acknowledgements: This research was funded by the ERC under the EU's 7th Framework and H2020 Programmes (ERC Grant Agreement no. 615517 and 963924), the Flemish Government (AI Research Program), and the FWO (project no. G091017N, G0F9816N, 3G042220). Part of the experiments were conducted on pseudonimized HR data generously provided by VDAB.