# Bullying Detection through Graph Machine Learning

Applying Neo4j's Unsupervised Graph Learning Techniques to the Friends Dataset



### Background





### Research Questions

### **RQ1**:

How can unsupervised GML techniques in Neo4j be applied to the Friends dataset to identify patterns or clusters that may indicate bullying behavior?

#### RQ2:

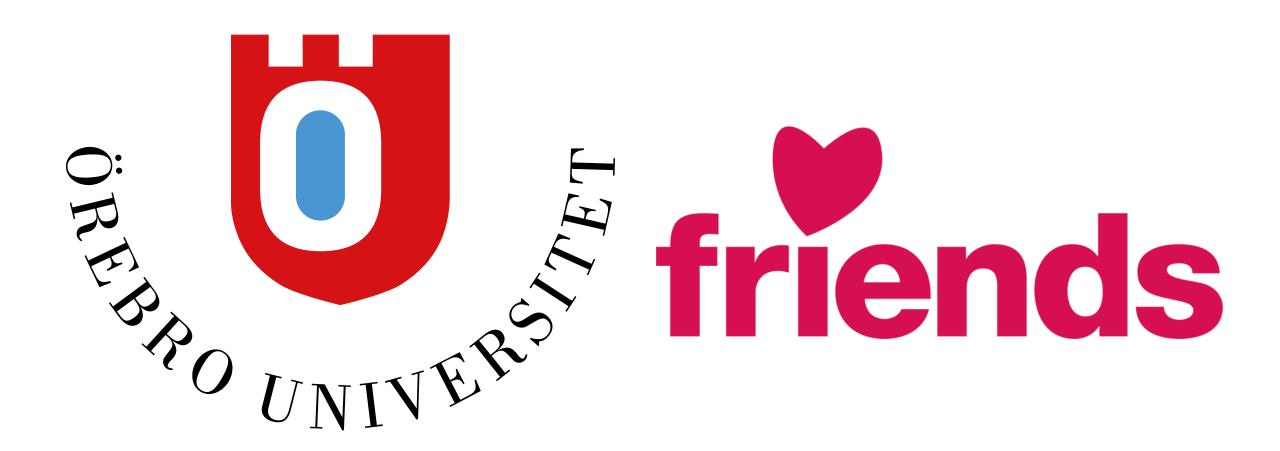
How can these patterns, combined with domain knowledge from behavior science, be used to reveal hidden relationships that can indicate a likelihood of bullying?



## Methodology

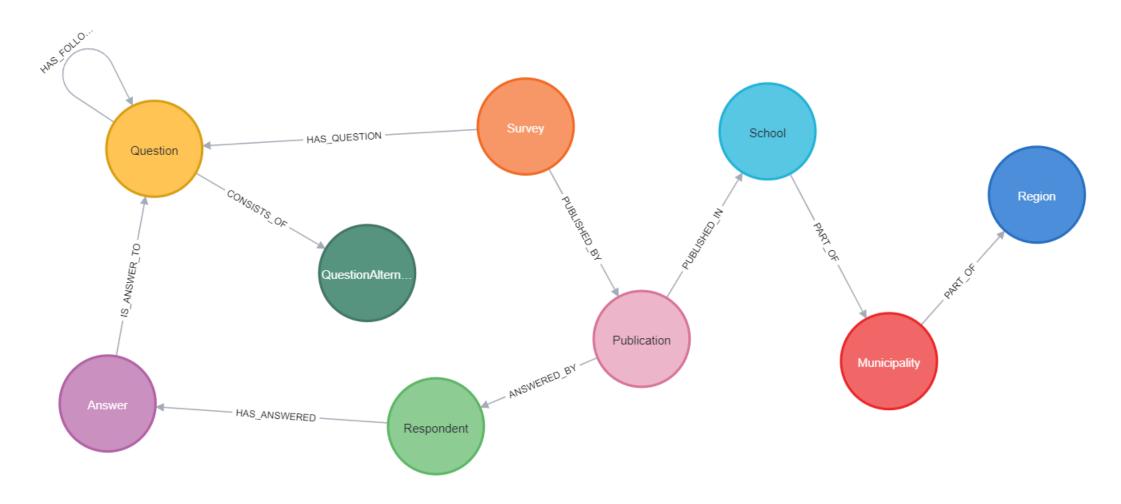


### Methodology – Collaboration



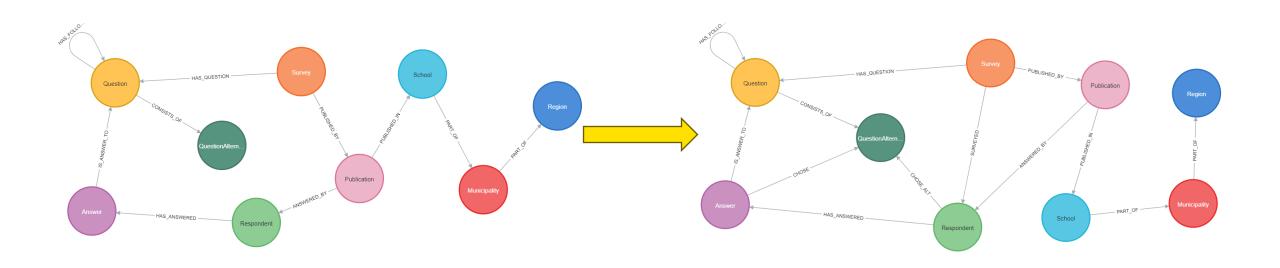


### Methodology – Neo4j





### Methodology – Data Preprocessing





### Methodology - Indices

NormalityIndex<sub>s</sub> = 
$$\frac{\sum_{i=1}^{n} \frac{\mathbf{a_i}}{\mathbf{q_i}}}{\mathbf{n}}$$

PositivityIndex<sub>s</sub> = 
$$\frac{1}{n} \sum_{i=1}^{n} \begin{cases} 1 - \frac{position_i}{total\_position_i}, & \text{if } is\_positive_i = 1\\ \frac{position_i}{total\_position_i}, & \text{otherwise} \end{cases}$$



### Implementation & Results



# Implementation – Louvain



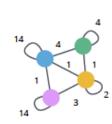


Choose a start node and calculate the change in modularity that would occur if that node joins and forms a community with each of its immediate neighbors.



Step 1

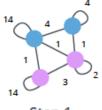
The start node joins the node with the highest modularity change. The process is repeated for each node with the above communities formed.



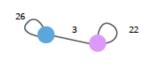
Step 2

Communities are aggregated to create super communities and the relationships between these super nodes are weighted as a sum of previous links. (Self-loops represent the previous relationships now hidden in the super node.)





Step 1



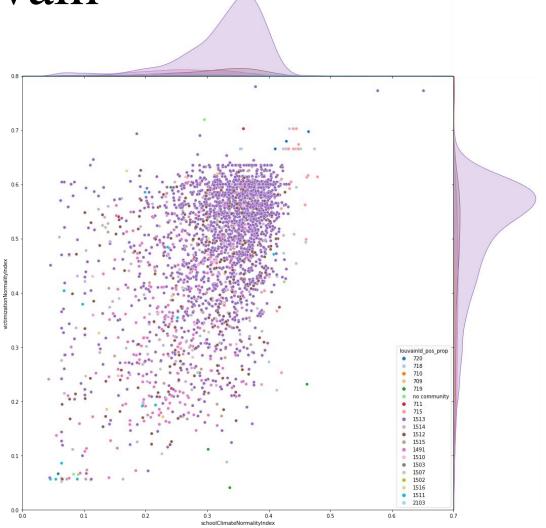
Step 2

Steps 1 and 2 repeat in passes until there is no further increase in modularity or a set number of iterations have occurred.

Source: Adapted from [3]

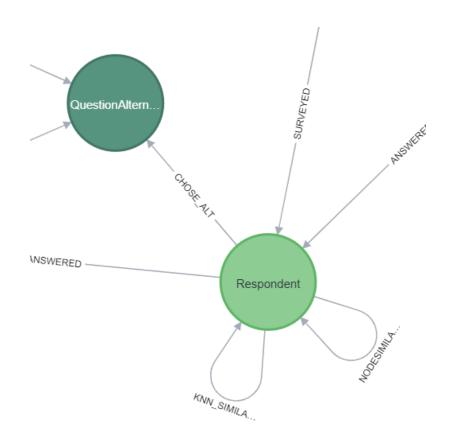


### Results – Louvain



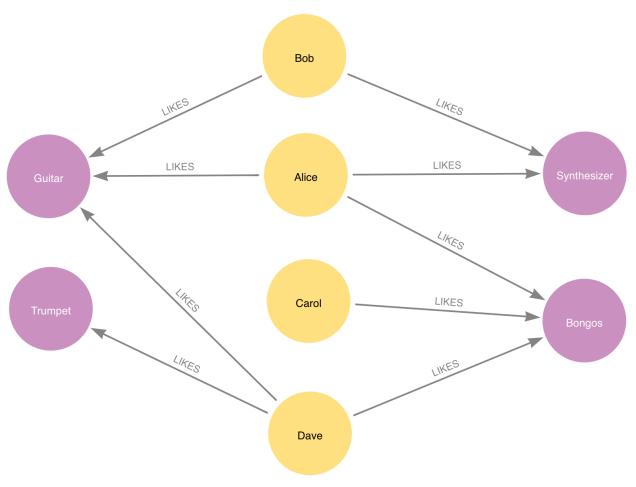


### Implementation – Similarity



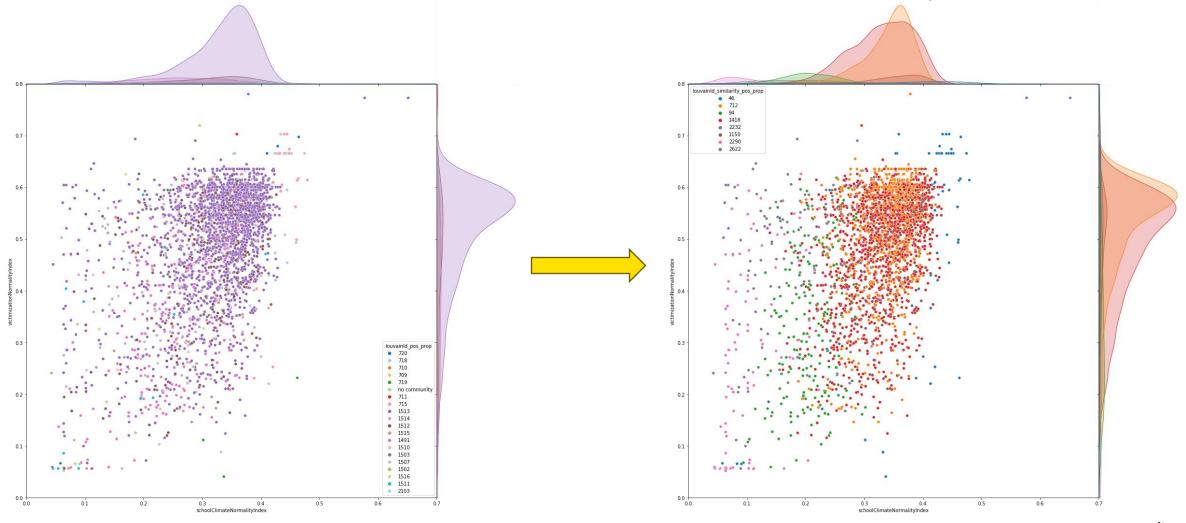


### Implementation – Node Similarity





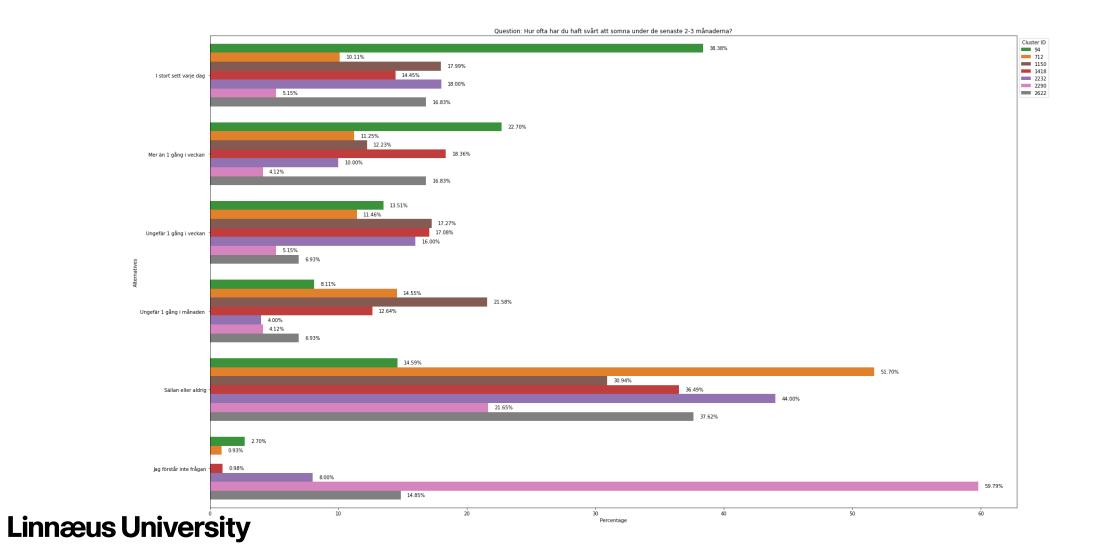
### Results – Louvain with Node Similarity





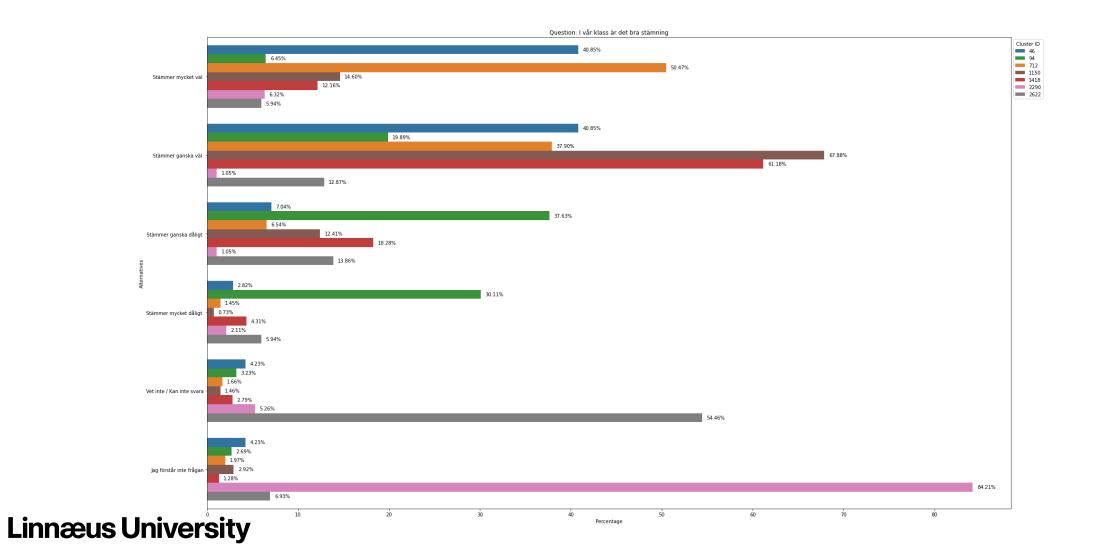


### Results – Louvain – Victimization



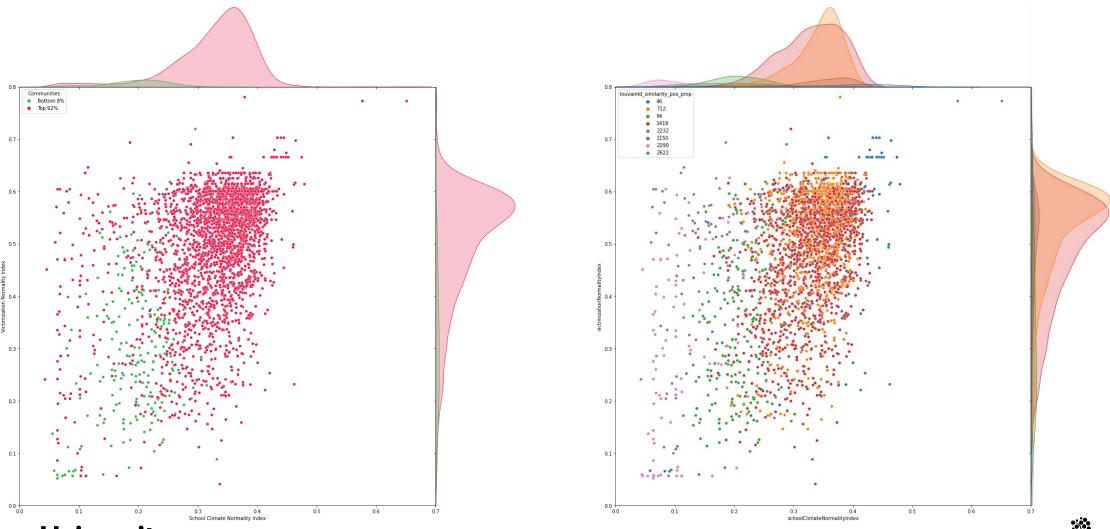


### Results – Louvain – School Climate



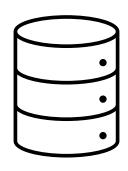


### Results – Simulated Expert Predictions



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### Future Work









### References

- [1] Neo4j, "Node Similarity" [Online]. Available: <a href="https://neo4j.com/docs/graph-data-science/current/algorithms/node-similarity/">https://neo4j.com/docs/graph-data-science/current/algorithms/node-similarity/</a> [Accessed: 2023-05-22]
- [2] M. Needham and A. Hodler, "Graph Algorithms in Neo4j: Label Propagation" [Online]. Available: <a href="https://neo4j.com/blog/graph-algorithms-neo4j-label-propagation/">https://neo4j.com/blog/graph-algorithms-neo4j-label-propagation/</a> [Accessed: 2023-05-22]
- [3] M. Needham and A. Hodler, "Graph Algorithms in Neo4j: Louvain Modularity" [Online]. Available: <a href="https://neo4j.com/blog/graph-algorithms-neo4j-louvain-modularity/">https://neo4j.com/blog/graph-algorithms-neo4j-louvain-modularity/</a> [Accessed: 2023-05-22]





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