Map of Technology: Topic modeling full-text patent data

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INTRODUCTION

JUSTIFICATION

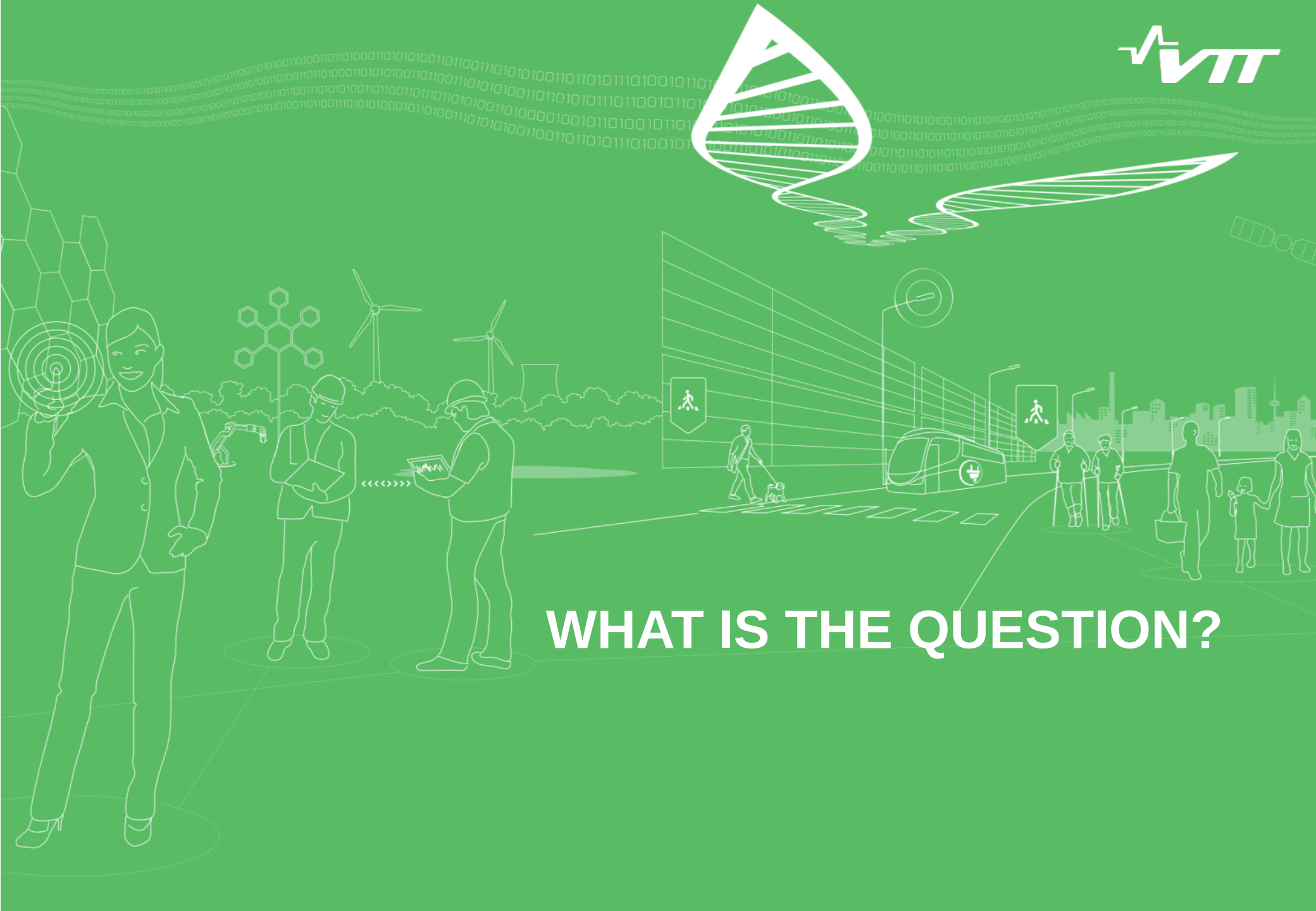
- A central challenge for the mapping patents is the creation of valid and accurate coordinates.

CONTRIBUTION

- Our study discusses the choice of the origin of coordinates in order to make a map of technology, and, in particular, demonstrates the advantages of unsupervised learning-assigned coordinates over those created by human reasoning.

INTRODUCTION

- Previous studies on mapping patent information:
  - specifically focusing on patent maps e.g. Yoon et al. (2002); Lee et al. (2009); Kim et al. (2008)
  - citation analysis e.g. Karki (1997) and Daim et al. (2006)
  - technology roadmapping e.g. Yoon and Phaal (2013)
  - Text mining e.g. Tseng, Lin and Lin (2007)
- Above example are not an exhaustive list.


WHAT IS THE QUESTION?

INTRODUCTION

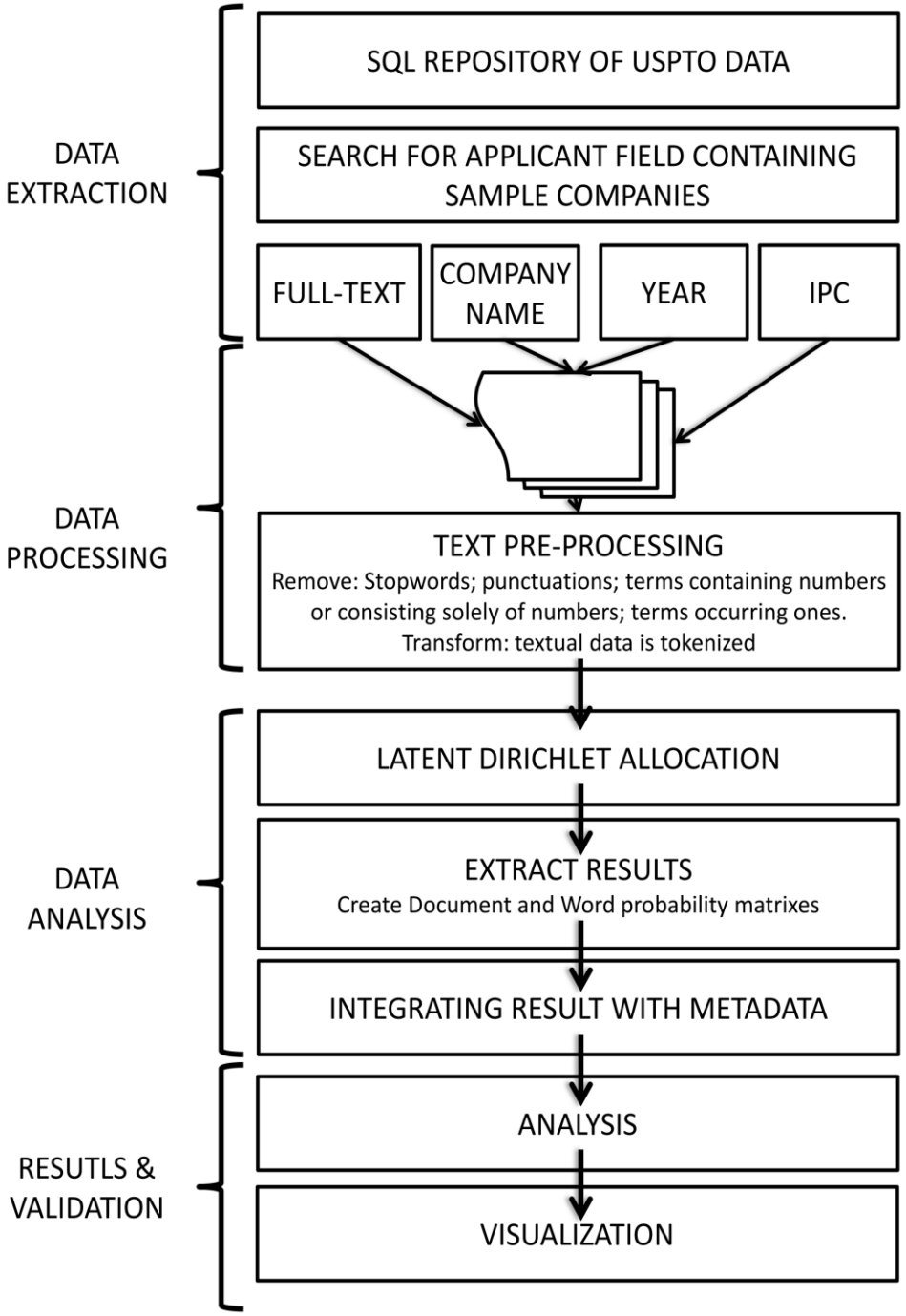
- Using patent classifications to form a patent map is not without limitations.
- Connecting patent classifications directly to industry sectors is challenging.
  - Classifications are also of limited value in directing inventive effort
  - The human process related to assigning classes to patents is valuable in the patenting process, even to the extent that automated classifications fall short of providing similar results.
- ARGUMENT: Machine-learning can offer an alternate structure of coordinates for patent data that creates deeper understanding on how technology is created

UNSUPERVISED LEARNING

- Produces an outcome based on an input while not receiving any feedback from the environment.
  - reliance on a formal framework that enables the algorithm to find patterns.
- Topic models " ...can extract surprisingly interpretable and useful structure without any explicit "understanding" of the language by computer". (Blei & Lafferty 2009)
- As a simplification each document in a corpus is a random mixture over latent topics, and each latent topic is characterized by a distribution over words.

DATA, PRE-PROCESSING AND ANALYSIS

- SAMPLE: one year of patent applications
  - We assume one year of patenting representing a adequate sample of patents to use as a basis of analysis.
- DATA: full-text patent descriptions filed in the USPTO containing approximately 6 million patents. The repository, hosted by Teqmine Analytics Ltd
  - The analysis was limited to 2014.
  - Final data contains 374,704 full-text records.



ALGORITHM: LDA

The algorithm is based on an online variational Bayes algorithm for LDA [9]

Number of Topics used was set using a trial-and-error & Arun et al. (2010) approach to 200.

IMPLEMENTATION: Python

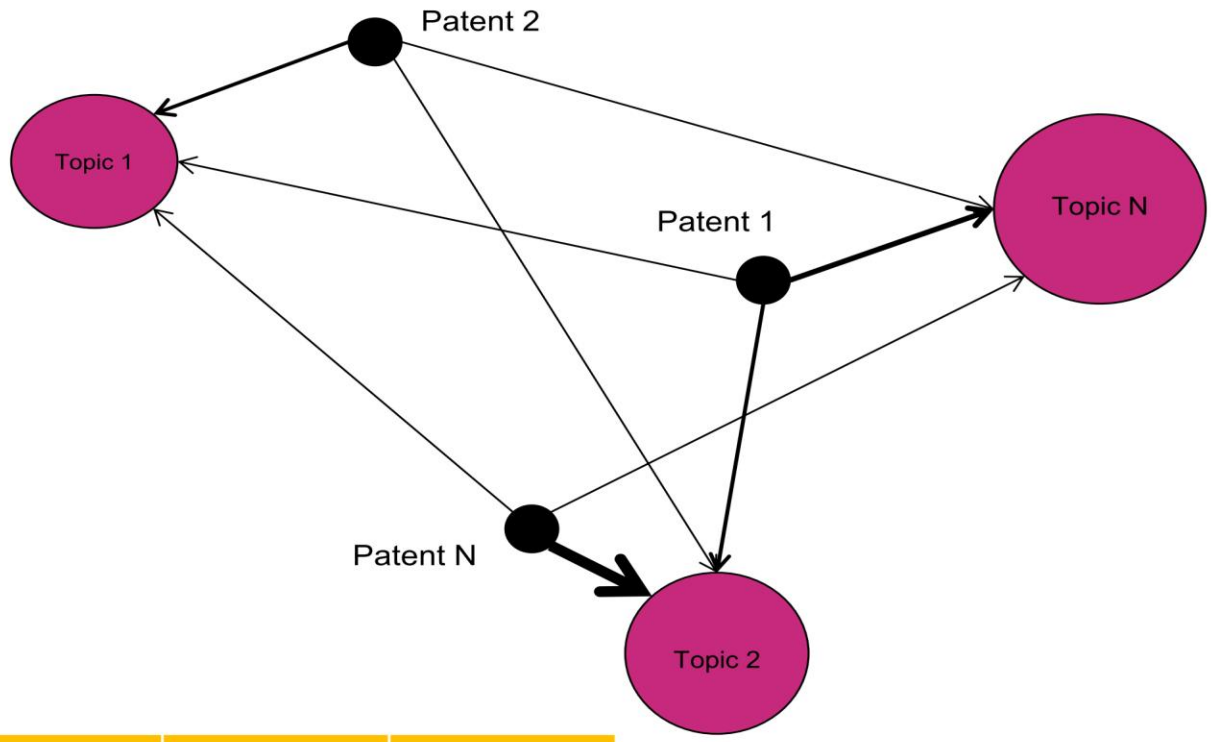
Python implementation included pre-processing

ANALYSIS: Python, Gephi & R

Networkx package in Python was used to decompose two-mode network data

Gephi was used to create visuals from the soft classification created by the algorithm. The modularity algorithm within Gephi was used to cluster network data.

R was used for additional calculations



	Topic 1	Topic 2	…	Topic N
Patent 1	0.10	0.24		0.40
Patent 2	0.40	0.01		0.10
…				
Patent N	0.01	0.80		0.01

RESULTS

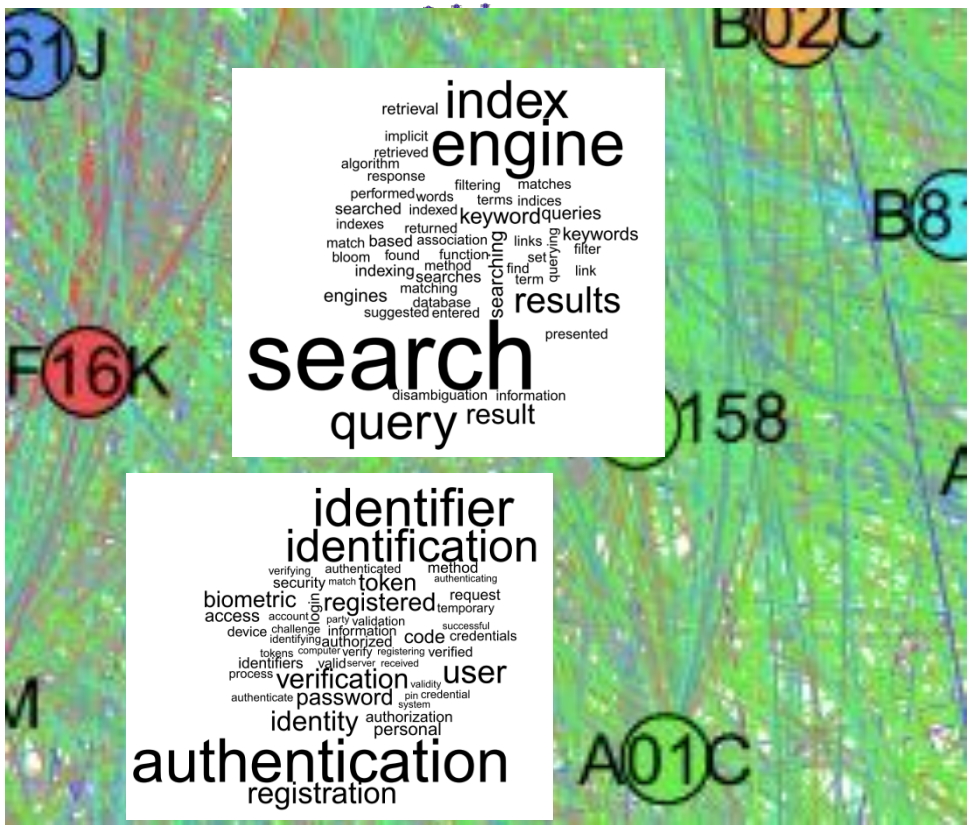
RESULTS

- RAW OUTPUT FROM ALGORITHM:
  - A soft classification of document probabilities to belong in a topic
  - A probability matrix of token probability to belong in a topic.
- RAW DATA TRANSFORMATION:
  - Document probability data was transformed to bipartite networks data using a Python script
    - Nodes are defined as Unsupervised learning based topics and IPC classifications
    - To diminish complexity patent data classes were limited to the third sub-classification
    - Edge weight is derived from topic IPC class co-occurrences. Counting was done with a fractionalized counting scheme.
    - Networkx package was used to create a one-mode projection of the data.

RESULTS

- VISUALIZATION:
  - Gephi was used to visualize networks.
    - OpenOrd and Fruchterman-Reingold algorithms were used to define node positions.
    - Modularity algorithm by Blondel et al. (2008) was used to derive latent clusters in the networks. Algorithm was run with several resolutions.
- ADDITIONAL ANALYSIS
  - Case by case analysis of unsupervised learning topics and IPC classes

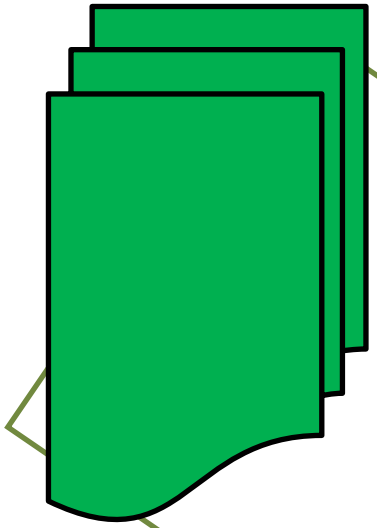
Bipartite network

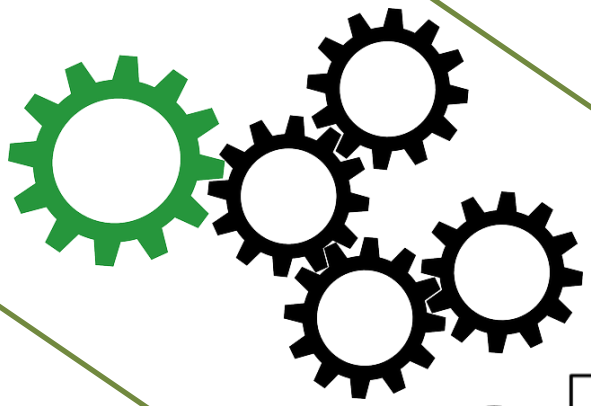


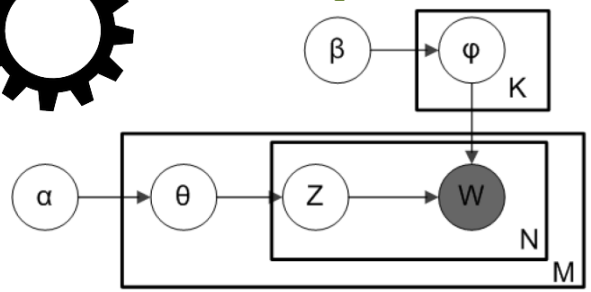
- Bipartite network show unsupervised learning and IPC class nodes and weighted edges based on a fractional counting scheme.
- Figures are drawn from a 818 nodes (topics and IPC classes) and 18373 edges between nodes.
- Merging the two modes are challenging – what is the counting scheme versus probability scoring of documents?

One-mode projection

- Python Networkx package was used to project the bipartite graph to one-mode projection
- Figures are drawn from 200 unsupervised learning based topics (nodes) and 19773 edges between nodes.






β
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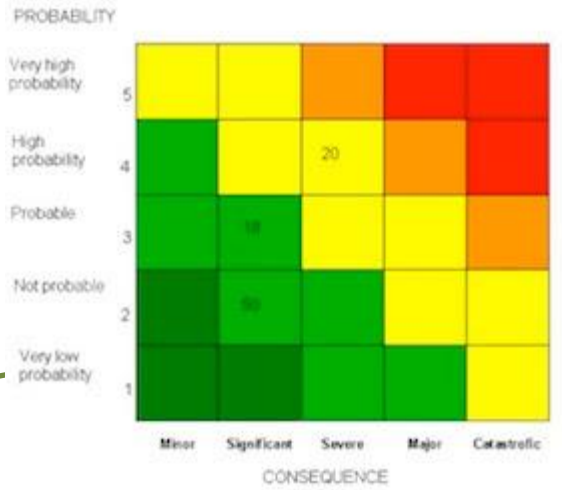
PROBABILITY
Very high probability
High probability
Probable
Not probable
Very low probability
5
4
3
2
1
20
Minor
Significant
Severe
Major
Catastrofic
CONSEQUENCE

Conclusions

- Unsupervised learning offers an approach to classify large semantic datasets.
  - Optimally uncovering latent patterns without human intervention.
- Data represents a key challenge
  - What is the amount of preprocessing done that keeps semantic variability but loses noise.
- Merging automated classes and human given labels should be unproblematic – keeping that both are in a sense correct
  - However, weighting schemes used in this study seem to through the analysis of at several stages.

QUESTIONS?

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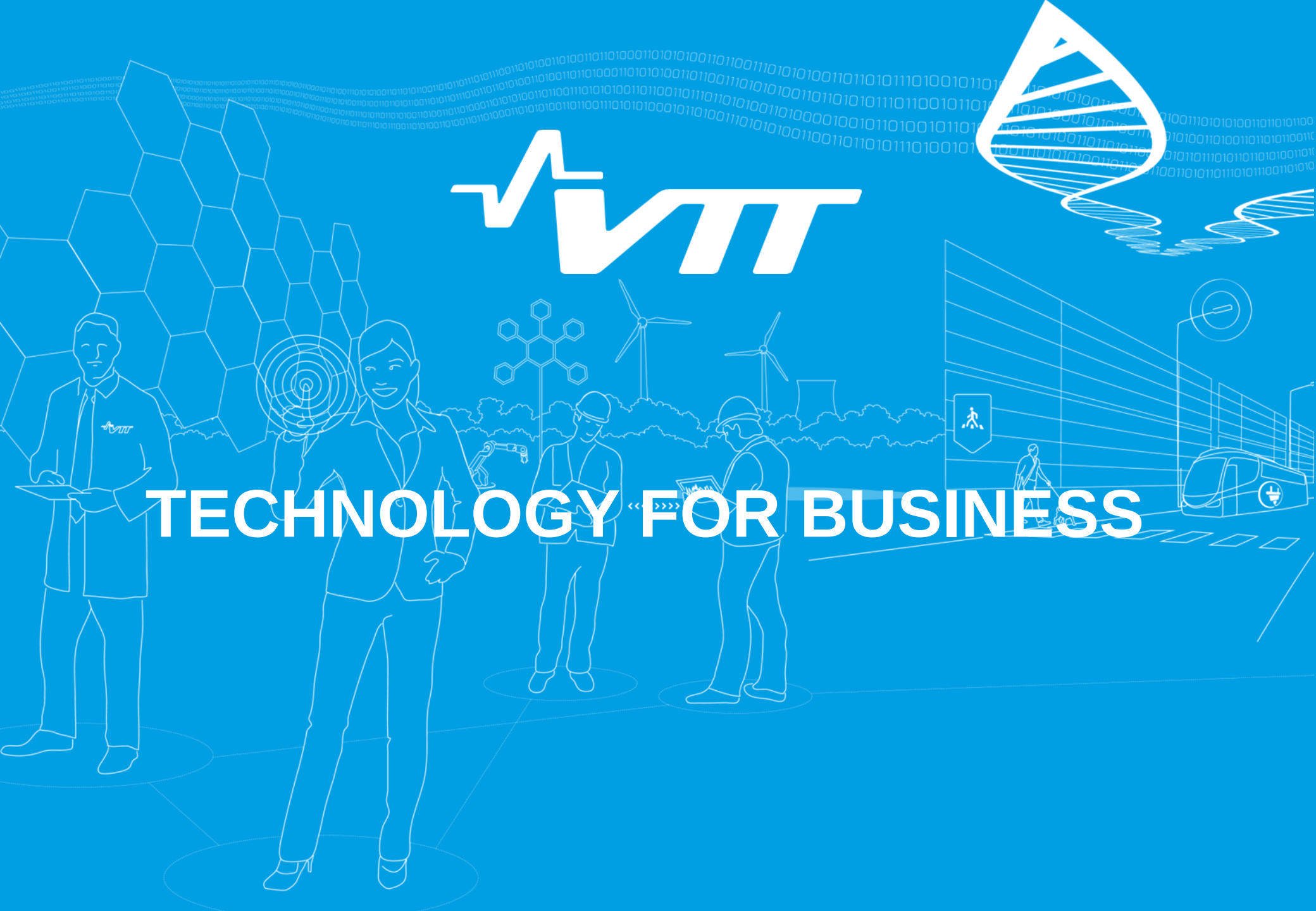
TECHNOLOGY FOR BUSINESS