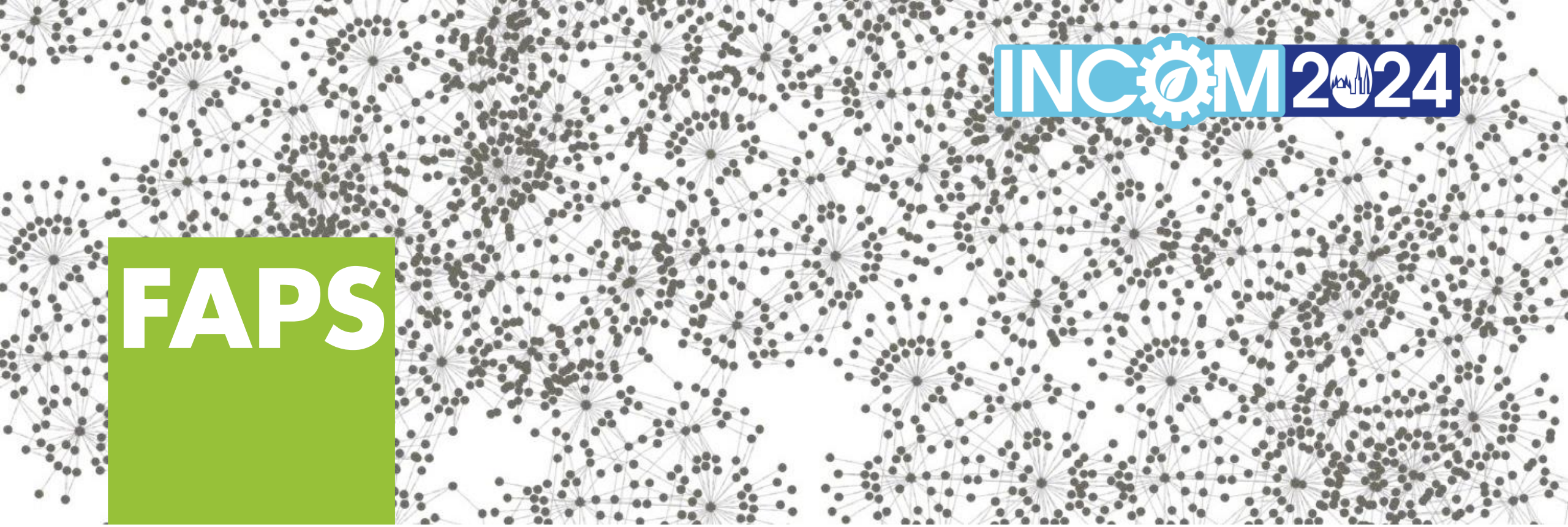

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Optimization of Process, Knowledge, and Manufacturing Management in Customized Production:

A Graph-Based Approach for Manufacturing Planning

30.08.2024, INCOM, Vienna

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The Institute for Factory Automation and Production Systems (FAPS) is researching the production and assembly of mechatronic products.

1 Introduction and Need for Action

2 Research Aim

3 Methodology

4 Findings

5 Summary and Further Research

Researchgate:

M.Sc.

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Disciplines:

- Industrial Engineering, Mechanical Engineering, Manufacturing Engineering
- Research Associate / PhD student in the research area Data and Power Networks
- Focus on: Digitalization and data consistency in variant-rich production of complex mechatronic systems

Current Projects:

- Digital Transformation of the Control Cabinet Industry
- Automated Recycling of complex Mechatronic Products via Deep Learning

During the evaluation of processes within Control Cabinet Building operations that adhere to the ETO principle, issues were observed in the domain of production control.

Situation & Complication

Predominant problems:

- Manufacturing is based on implicit knowledge of a few employees
- Process intransparency leads to additional work
- Legacy systems and vendor lock-in prevent digitialization or effective production control

Interviews/Survey:

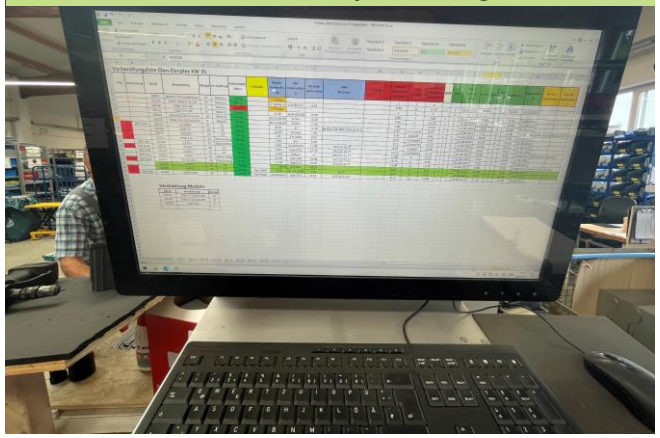
- Digitalization and standardization most frequently mentioned item in open question on most important trend in the next 5 years

Market overview

Data and media discontinuities

Intransparency & search times

Insufficient planning



The industry is challenged to innovate production processes in the age of digital transformation in order to remain competitive.

Industry 4.0

Industry 4.0 is an advanced technology and production strategy that focuses on the networking of machines, data and processes in the manufacturing industry.

Comprehensive transformation of industry through the digitalization and automation of every aspect of a company, especially manufacturing processes. This results in the following benefits:

- Competitiv advantage
- flexibility
- Saving costs
- Customer experience

Graph databases in manufacturing

The use of graph-based databases in knowledge, process and production management offers many advantages:

- Efficient analysis of relationships and conections between data points
- Process optimization: identification of bottlenecks and optimization of processes
- Resources can be allocated more efficienty
- Simplified visualization of complex relationships

Resulting research question

How can the technology of graph-based databases be adapted to control cabinet manufacturing in the context of knowledge, process and manufacturing management?

The outlined principles establish the foundational framework for the development of the graph-based database in control cabinet manufacturing.

- Neo4j stands as a leading graph-based database
- Utilizes the Cypher query language, specifically designed for navigating graph-based databases
- Scalable architecture of Neo4j allows for effective handling of both small and larg data sets
- Flexibility: Neo4j supports the storage of various types of data and relationships within a graph, making it ideal for applications where complex interconnections between data points are crucial

neo4j AuraDB Enterprise

applications

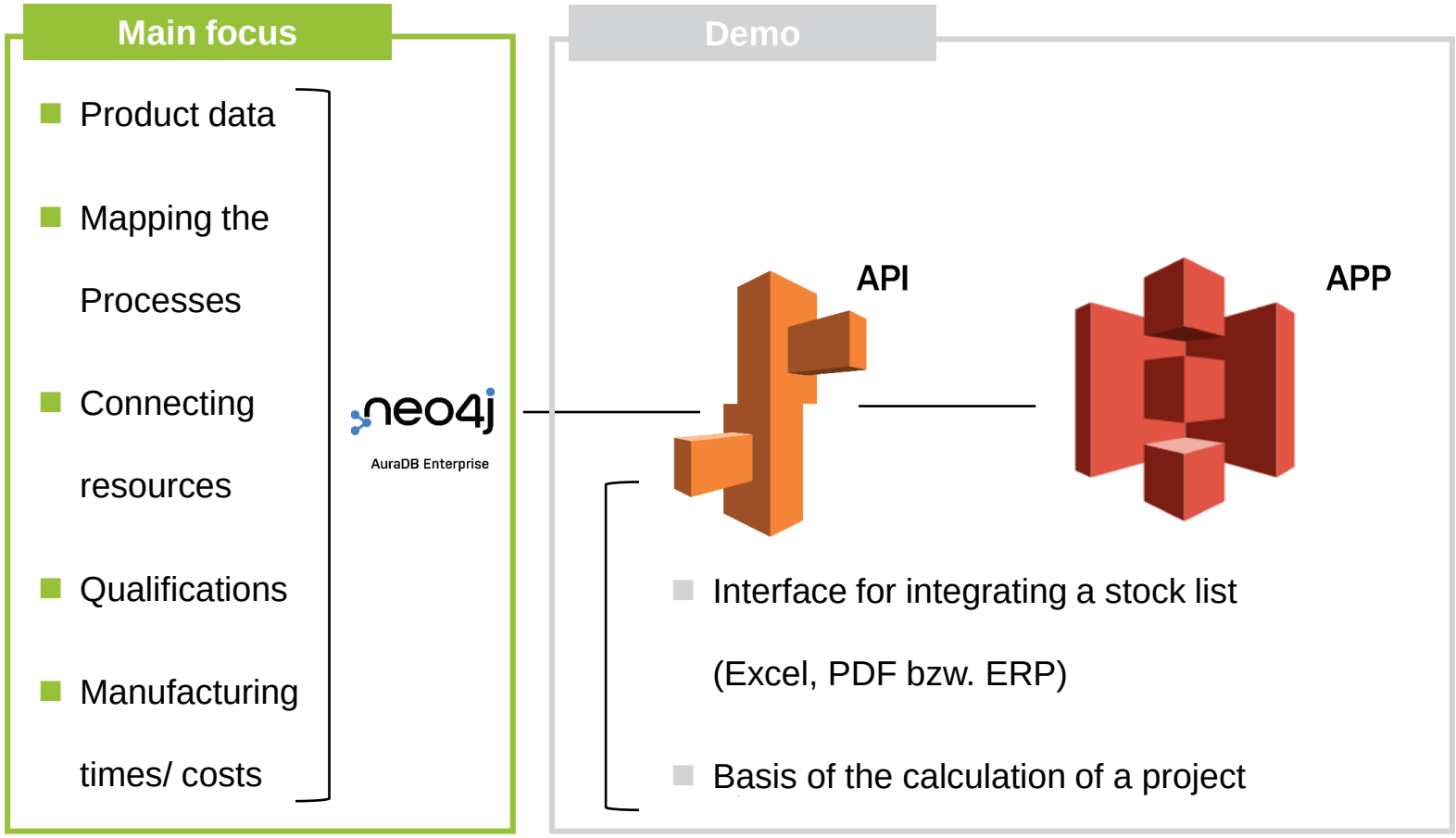
CLASS

- ECLASS is an international classification system for products and services
- ECLASS supports multiple languages and can be used in various countries and industries
- Supports various standards and norms to ensure interoperability between different systems
- ECLASS plays a key role in the digitization of business processes
- Ensured unique identification of products and facilitates the integration of product information into digital systems and platforms

Core Concept and Focus on Development: Database, Interface and User Interface with a Primary Emphasis on Database Design.

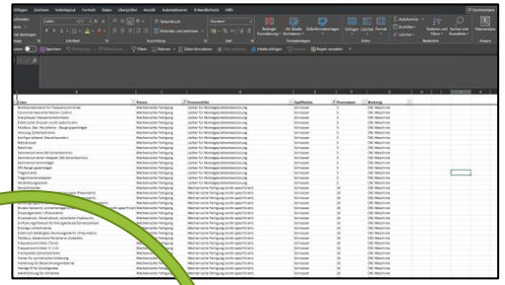
The fundamental concept for enhancing transparency in control cabinet manufacturing in based on the following components:

- Neo4j as the database
- Creation of an API to connect an Excel file
  - API facilitates data exchange between the bill of materials and Neo4j
  - Seamless connection and bidirectional data updating
- User interface (App) for database interaction
  - Visuell representation of costs, duration, qualifications and material



The focus lies on the development of the Neo4j database.

The approach of the work was divided into five steps and thus developed a guide for production control in control cabinet manufacturing.

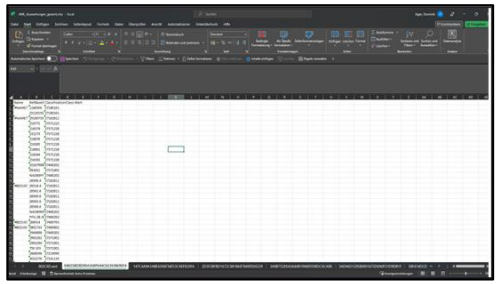


1 Abstraction of real control cabinet projects

- **Extract and abstract data** from multiple real BOMs and industrial partners
- **Develop a comprehensive database** for efficient project and production management

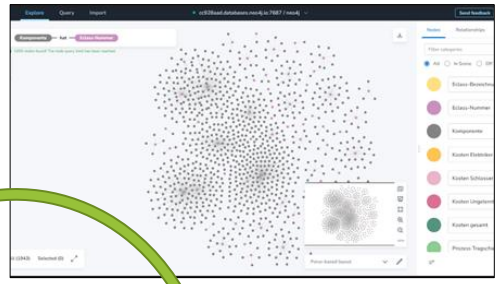
2 Data preperation and enrichment

- **Cleanse data** to remove inconsistencies and standardize using ECLAss standards
- **Enrich the database** with additional data from internal and external sources



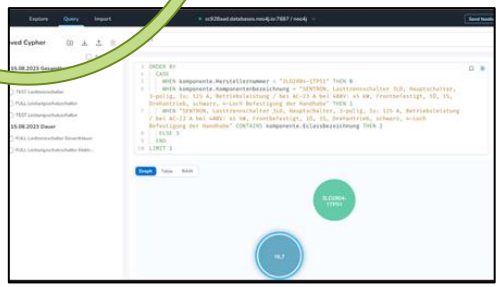
3 Importing and integrating data into Neo4j databse

- **Define and model data structures** and relationships within Neo4j
- **Efficiently integrate data** to enhance management and visualization capabilities



4 Analyzing the modeled database

- **Utilize Cypher queries** to analyze relationships and data flow
- **Validate database fucntionally** and the accuracy of the data model



5 Comparison with actual bills of meterials

- **Conduct comparisons** between the database entries and actual BOMs
- **Identify discrepancies** to improve database accuracy and suggest future enhancements

The abstraction of real control cabinet projects and the preparation and enrichment of the data are key steps in creating a precise but standardized component list.

Data Foundation Establishment and Component List Compilation:

- Extraction of relevant data points from 26 bills of materials from real control cabinet construction projects provided by industrial partners
- This enabled the development of a substantial database for control cabinet construction, with a list of 1,468 elements
- The following data points were included in this initial version: manufacturer, name and ECLASS number
- These data formed the basis for the development of the database and queries

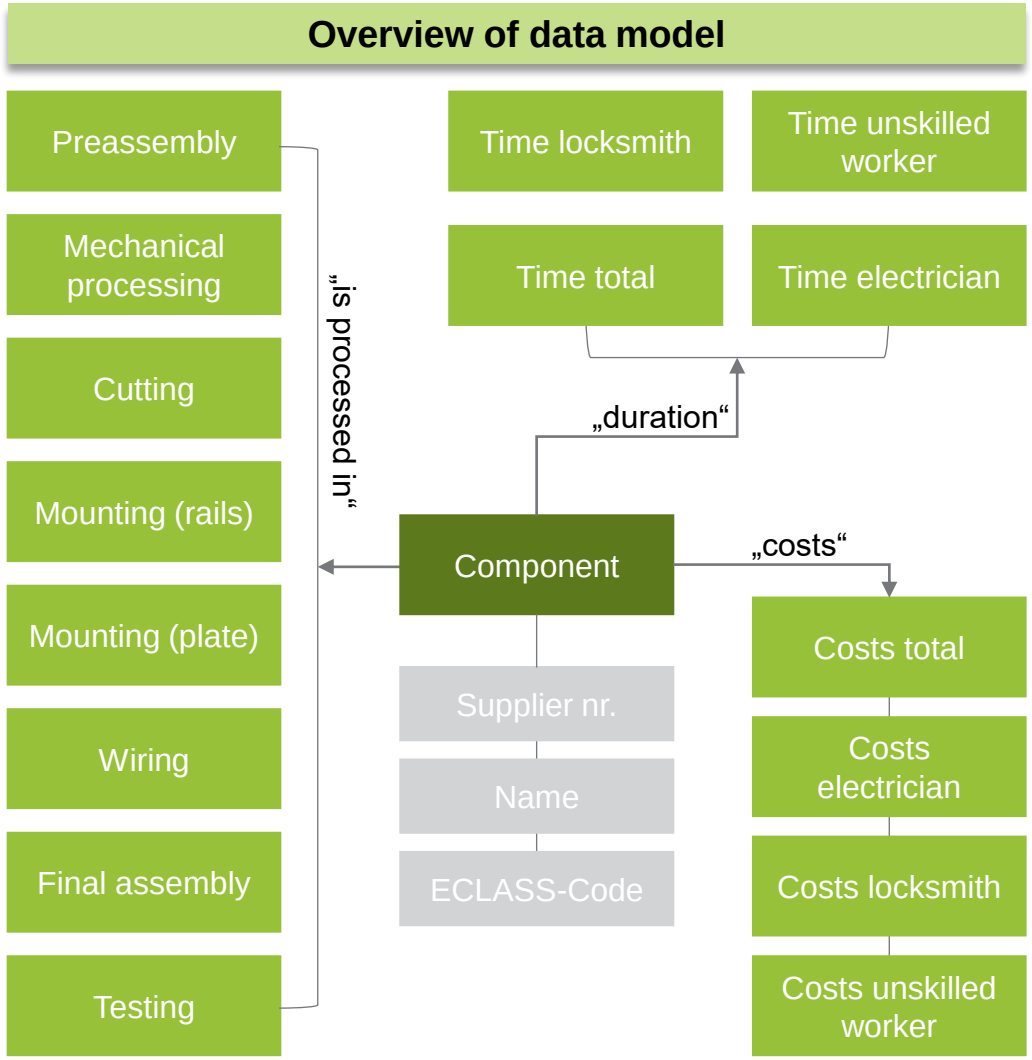
Refinement and Augmentation of the Component List with Procedural and Economic Data

- Utilization of a central foundation for information in control cabinet construction
- Analysis of ECLASS numbers in the bills of materials to identify specifications and descriptions
- Incorporation of information on process steps with corresponding process times and qualification requirements
- Integration of production costs per qualification level

Import and integration of the data into Neo4j, followed by the development of a component-centered process and data model for enhanced data analysis.

AuraDB serves as a cloud database platform for managing, visualizing and modeling Neo4j databases:

- Mapping of data to entities and assembly steps for each
- Consideration of production and assembly steps for each component.
- Inclusion of costs and production times for economic evaluation and planning.
- Creation of relationships between nodes in the Neo4j database
- The component as a central element to enable economic calculation of a bill of materials



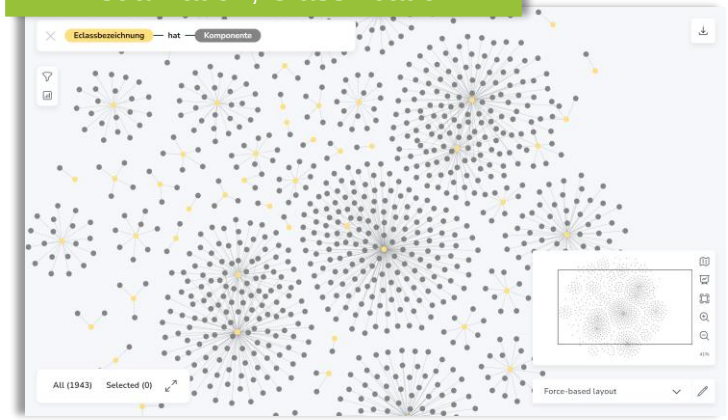
Creation of initial graphs and Cypher codes using the Neo4j AuraDB user interface to analyze the modeled database for consistency and errors.

Verification of the relationships between the entered components and their attributes:

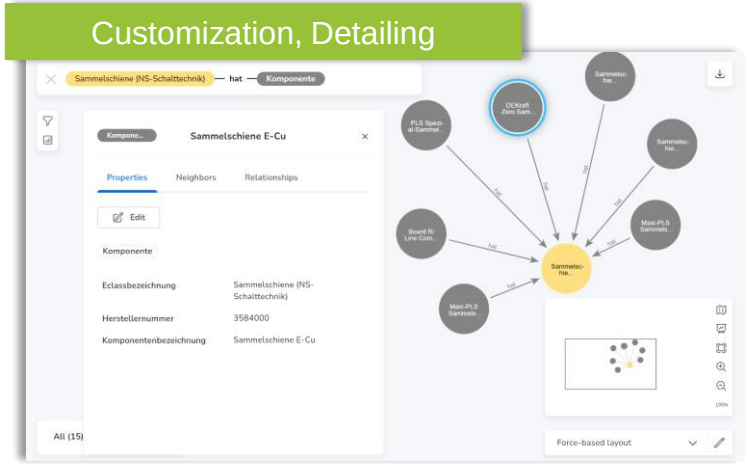
- Using intuitive input forms, data and relationships can be examined without programming knowledge
- This allows for the creation of specific content or general overviews
- Visual and tabular representation of query results
- Creation an execution of Cypher queries for systematic verification of the database.
- Queries to confirm the applicability of the model and ensure data consistency and correctness

Example queries for various components and aspects (total costs, electrician efforts, time requirements, processing steps, qualifications)

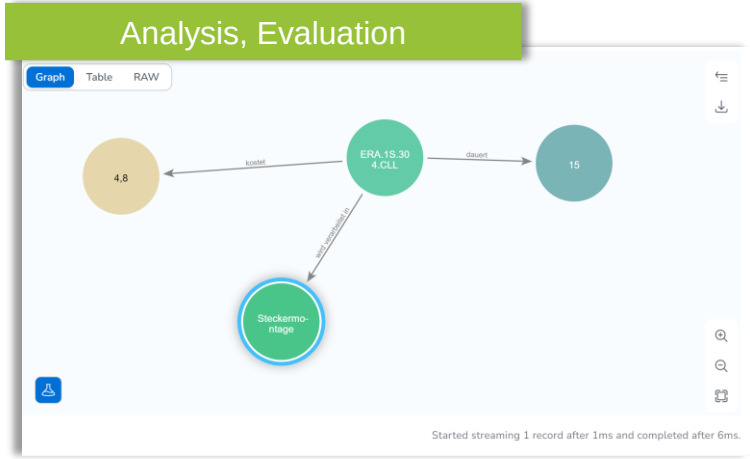
Visualization, Classification



Customization, Detailing



Analysis, Evaluation



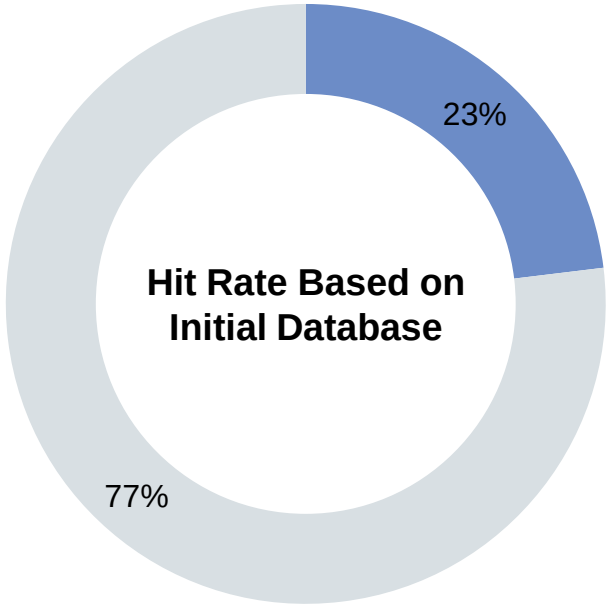
Validation of Assigning Non-Database Components to correct ECLASS and Corresponding Attributes.

Target of the Concept

- The goal of the tool is to assign components that are not directly know to the database to the correcct ECLASS
- Allows for the output of values related to their production costs, times and the qualifications required for processing

Technical Implementation

- Extraction of randomly selected components from actual bills of materials and manufacturer catalogs
- Data includes manufacturer number and component designation
- Cypher code in Neo4j uses fuzzy matching to compare database entries with external reference data
- Database results are compared with the original data from the manufacturers
- Out of the external data sets, 77% were correctly assigned



Developing a Comprehensive System for Control Cabinet Manufacturing to Optimize Production Times, Costs and Qualifications.

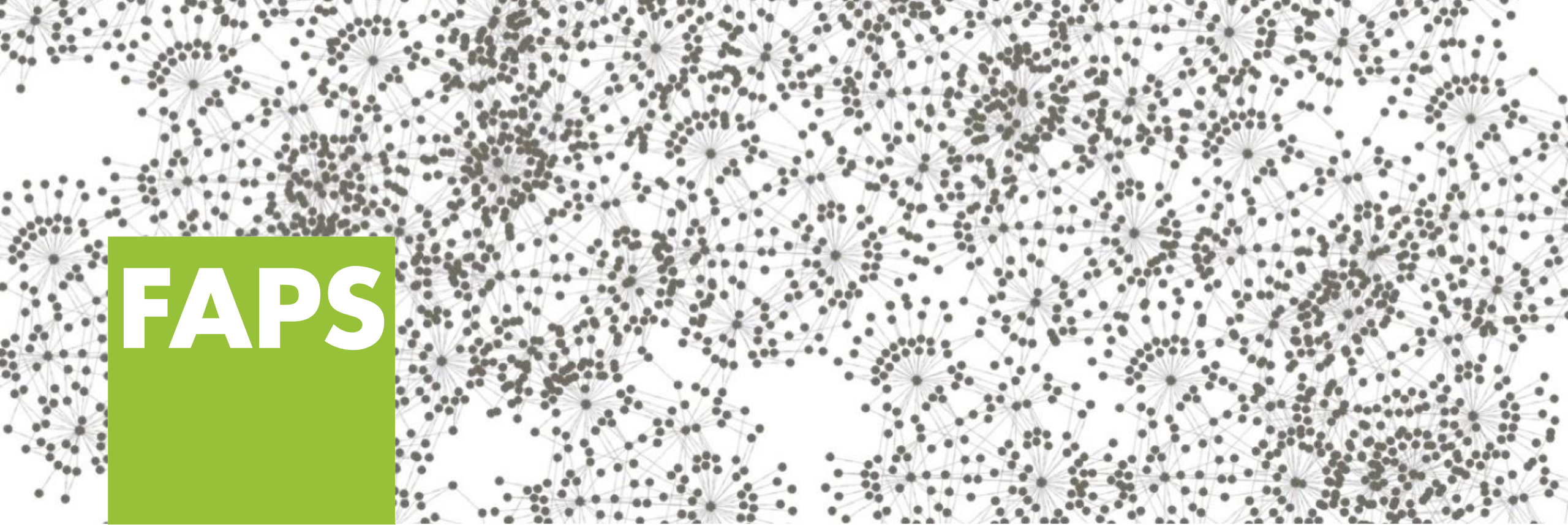
Summary

- Target: Concept for a Neo4j database in control cabinet manufacturing
- Background: Digitalization to optimize process, knowledge and manufacturing management
- Challenges in Control Cabinet Manufacturing: Transparency, outdated methods, high investment costs
- Development in Five Steps: Abstraction, data enrichment, modeling in Neo4j, analysis, comparison
- Database Basis: 26 bills of materials, 1,468 components with ECLASS and manufacturer number
- Import into Neo4j: 1,913 node, 16,102 relationships
- External Data Validation: 77% of components successfully assigned

This work serves as the foundation for a comprehensive system to calculate production times, costs and qualifications in control cabinet manufacturing, utilizing an Industry 4.0 approach to enhande competitiveness.

Further development of the Topic

Further development of the overall system: Establish automated data processing, program user interface; increase data quantiy, optimize similarity checking



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THANK YOU

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