Big Data Management Systems - Semester Project 2025: Graph Databases | Neo4j

In this project, we explored large-scale social network analysis by loading the MOOC User Action Dataset into Neo4j, running complex Cypher queries, and visualizing user interactions to uncover insights about online learning behaviors.

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📖 Overview

We explored large-scale social network analysis by loading the MOOC User Action Dataset into Neo4j, running complex Cypher queries, and visualizing user interactions to uncover insights about online learning behaviors. This project demonstrates how graph databases and Python can reveal valuable patterns in online education platforms.

🚀 Features

- Efficient data preprocessing and integration with **Pandas**
- Bulk graph construction in **Neo4j** using **Python**
- Clear property graph model: Users, Targets, and PERFORMS relationships
- Batch Cypher query execution and performance benchmarking
- Automated results export to CSV
- Graph visualization with **NetworkX** and **Matplotlib**

🗂 Project Structure

```
.
├── results/              # Query outputs and visualizations
├── solution.ipynb        # Main Jupyter notebook (well-commented and ready to
run)
├── cypher_queries.txt    # All Cypher queries used in the analysis
├── requirements.txt      # Python dependencies
├── README.md             # This file
```

Dataset

- **Source:** Stanford SNAP MOOC User Action Dataset
- **Files Used:**
  - `mooc_actions.tsv`
  - `mooc_action_features.tsv`
  - `mooc_action_labels.tsv`

Graph Model

- **Nodes:**
  - `User` (id)
  - `Target` (id)
- **Relationships:**
  - `(:User)-[:PERFORMS {action_id, timestamp, feature1, feature2, feature3, feature4, label}]->(:Target)`

Main Steps

1. **Data Loading:**
   - Read and merge the three original files using Pandas.
   - Extract and save unique users, targets, and all actions to CSV for Neo4j import.
2. **Neo4j Graph Import:**
   - Move all processed files to the Neo4j import directory.
   - Use Python and Cypher's `LOAD CSV` for efficient batch import, chunking actions for speed.
3. **Cypher Querying & Benchmarking:**
   - Execute a series of analytic Cypher queries.
   - Save results to CSV and print query timings.
4. **Visualization:**
   - Visualize a portion of the graph (users, targets, actions) using NetworkX and Matplotlib.

Example Queries

- Count all users, all targets, all actions
- Show all actions (actionID) and targets (targetID) of a specific user
- For each user, count their actions
- For each target, count how many users have done this target
- Count the average actions per user
- Show userID and targetID for actions with positive Feature2
- For each targetID, count actions with label "1"

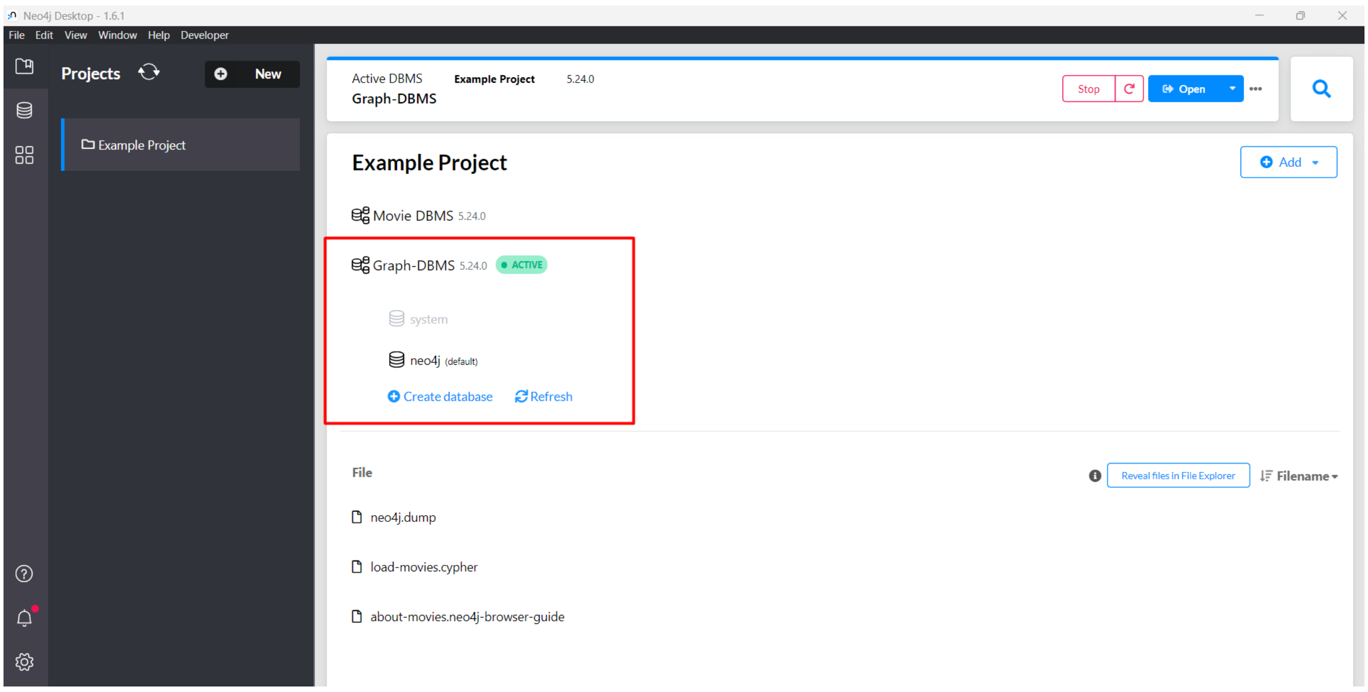
All queries are in cypher_queries.txt.

How to Reproduce

1. **Clone this repo**
2. Download the MOOC User Action Dataset and place it under `data/act-mooc/`
3. Open `solution.ipynb` and follow the steps (or run as a script)
4. Ensure your Neo4j Desktop server is running and the import directory path is correct
5. Run all cells to preprocess, import, query, and visualize

Setting Up Neo4j Desktop

Below is a screenshot of Neo4j Desktop with an active database (DBMS).
You must ensure your database is running and accessible before running the import steps.



You can locate the `import` directory for your DB by clicking "Reveal files in File Explorer" within the Neo4j Desktop UI.

Requirements

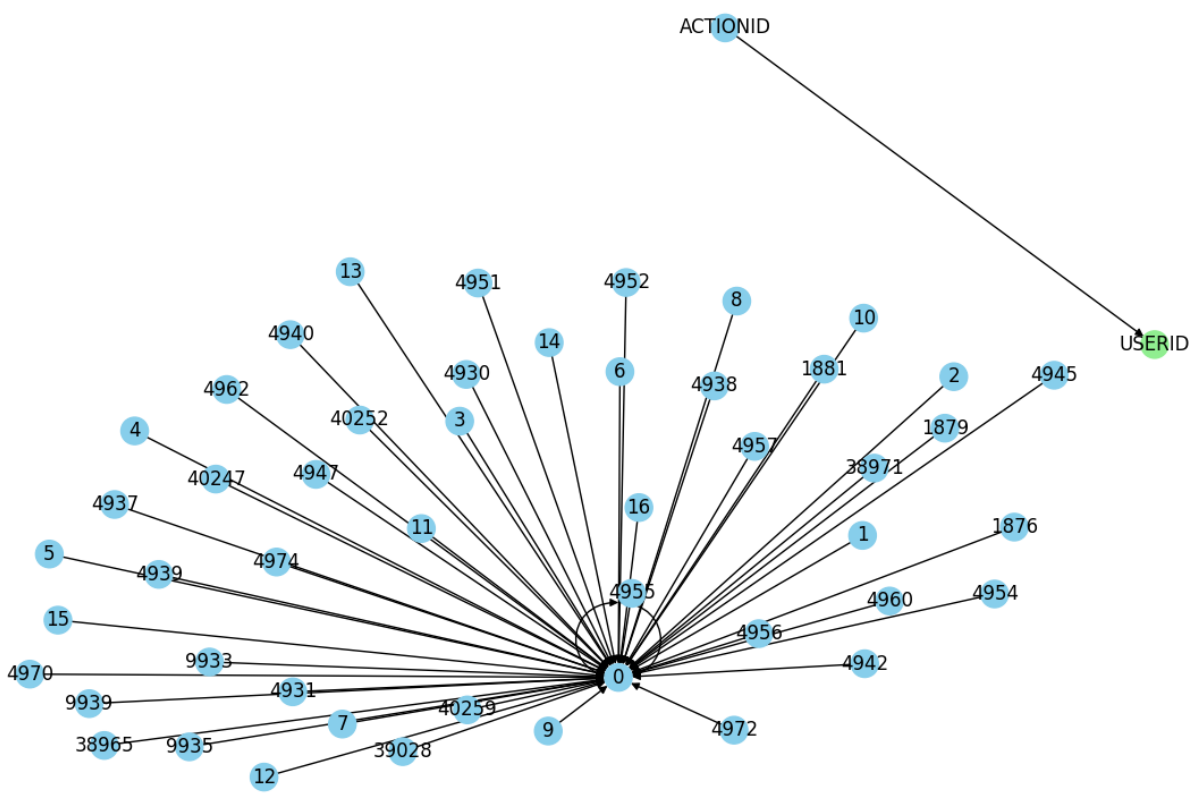
- Python 3.8+
- Neo4j Desktop
- `pandas`, `networkx`, `matplotlib`, `neo4j` (Python driver)

Install requirements with:

```
pip install pandas networkx matplotlib neo4j
```

📊 Graph Visualization

A sample of 50 `(User)-[:PERFORMS]->(Target)` relationships was visualized using NetworkX and Matplotlib.



Visualization Explanation:

- **Blue nodes:** represent individual `User` nodes (students).
- **Green nodes:** represent `Target` nodes (MOOC course resources or activities).
- **Directed edges:** show each action (`PERFORMS` relationship) from a user to a target.

Interpretation:
The graph exhibits a *hub-and-spoke* structure with a central user connected to many targets, demonstrating that users often interact with multiple resources in a MOOC.
The visualization validates the import and illustrates the many-to-many nature of online learning: one user can interact with many resources, and each resource can attract multiple users (not all shown here).
This structure helps us visually inspect the diversity of engagement and forms a foundation for further network analysis.

Environment & Dependencies

All dependencies are listed in `requirements.txt`. Key packages:

- `pandas`, `numpy`, `neo4j`, `networkx`, `matplotlib`, `tqdm`

To reproduce the environment:

```
pip install -r requirements.txt
```

Key Outcomes

- ~250k actions ingested into Neo4j
- Cypher queries automated and saved
- Interactive graph visualization created
- Schema successfully mapped: user–action–target

📌 Notes

- CSV files are automatically copied to Neo4j Desktop's `import/` folder by the Python code, provided that the user specifies the correct import directory path for their Neo4j database. Alternatively, this can be done manually if preferred.
- The database reset includes a 30-second wait time to avoid premature connections.
- Ensure Neo4j Desktop is **running** before executing Python scripts.

Authors

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