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Università di Camerino

Graphitect: BIM Data Integration and Visualization with Neo4j

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Project desciption / Objectives

1. Develop a Python-based tool to import and export Industry Foundation Classes (IFC) files into a Neo4j graph database, enabling advanced analysis and visualization of Building Information Models (BIM).

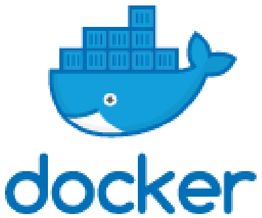
2. Graph analysis using the Neo4j GDS library (Graph Data Science).

3. Creation and connection of a custom IoT sensor into the BIM graph.

4. Export functionality to allow reuse and distribution of graph data.

🔗 https://github.com/Diego-m4i/TBDMProject

Methodologies and Technologies



neo4j/**graph-data-science**

Technical Implementation - Graph Deployment and Access

1.Deploy a Neo4j instance using Docker Compose;

2. Start the Neo4j Database and input Neo4j database
    - username → neo4j
    - password → diegodiego

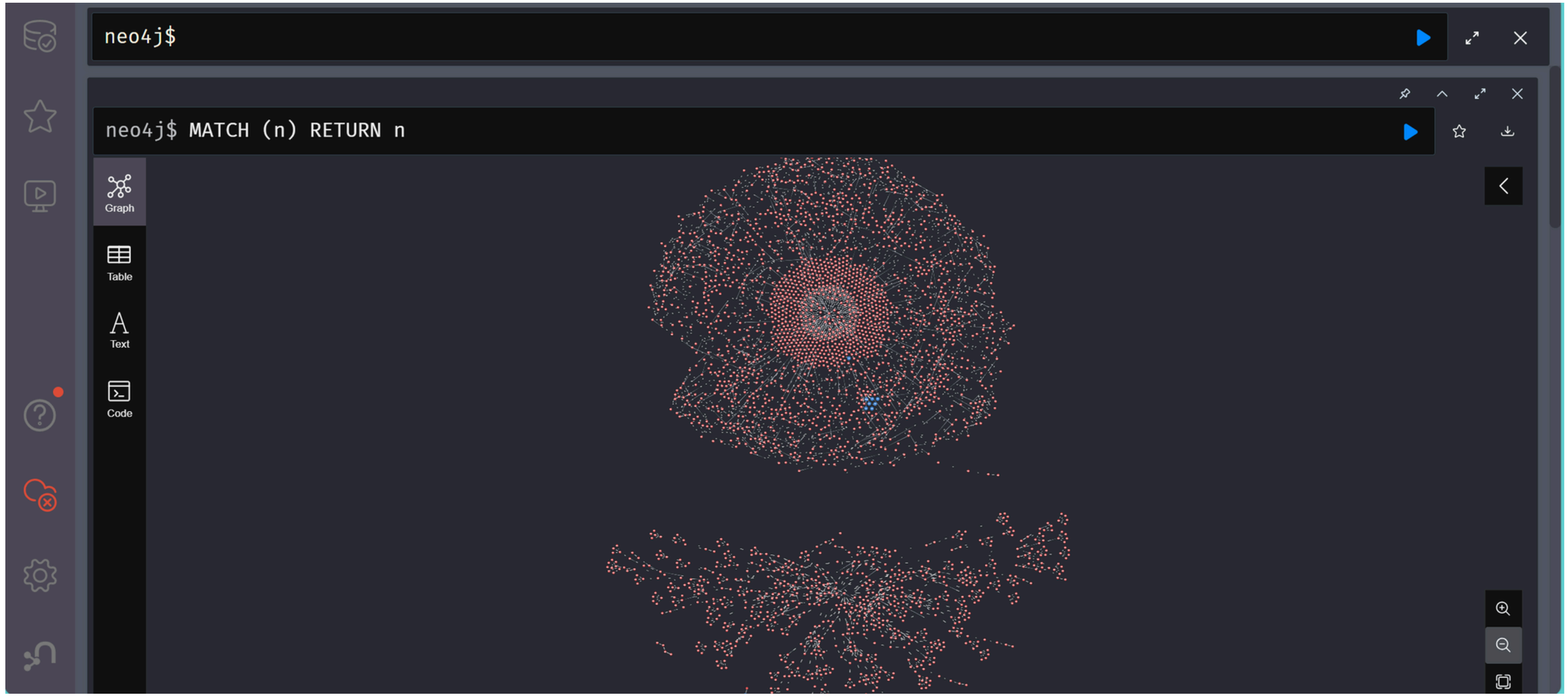
3. Access the database using Neo4j Database with the url:
http://localhost:7474/browser/

4. Project the graph for analysis

```
CALL gds.graph.project(
    'IfcOpenHouseGraph',  // Nome del grafo
    '*', // Tutti i nodi
    '*'  // Tutte le relazioni
    );
```

Achieved Results

A complete pipeline for importing and visualizing IFC data in Neo4j.



Achieved Results

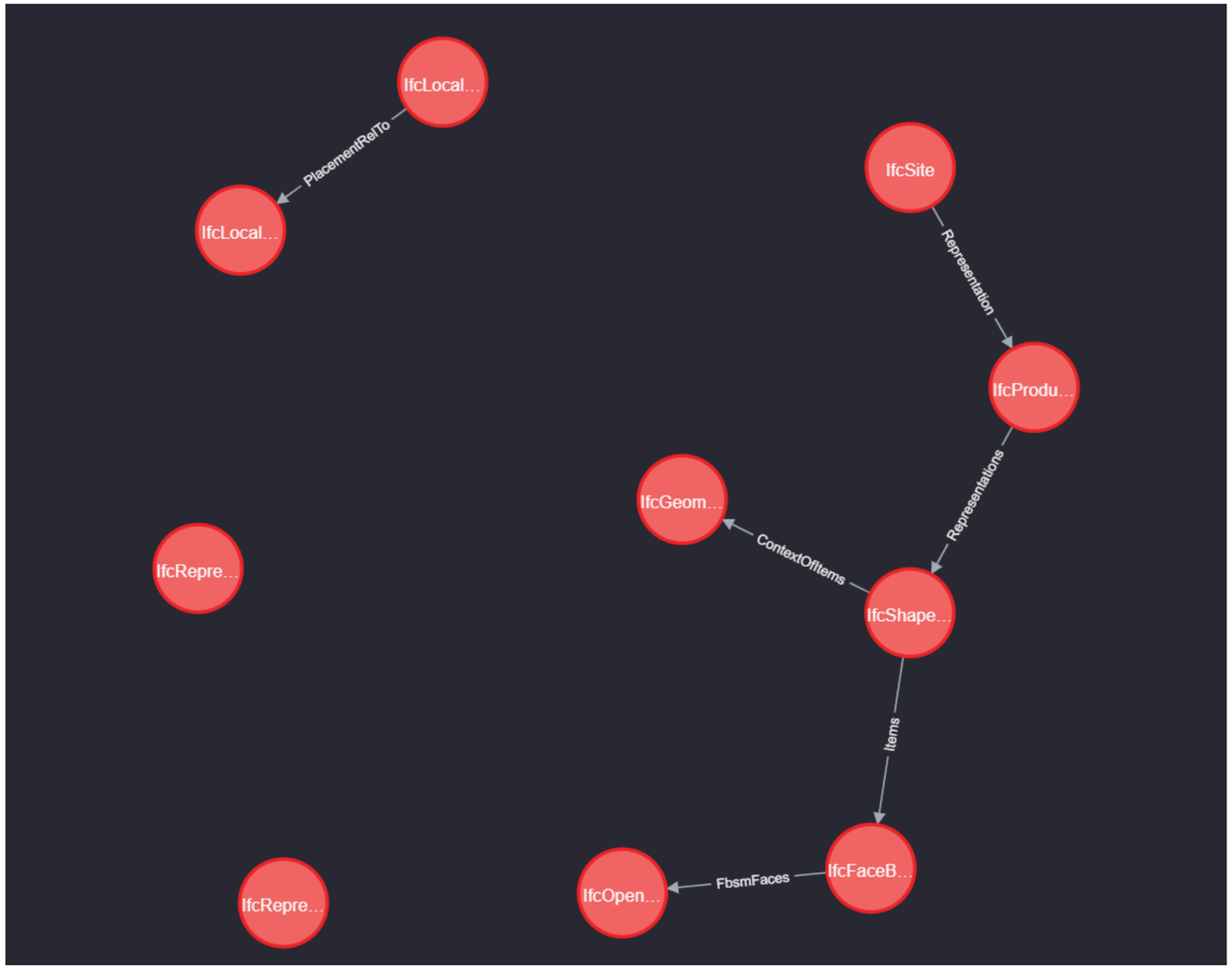
Graph centrality analysis

- Definition
- gds library
- class CentralityAnalyzer.py

```python
def get_centrality_data(self, limit=10):
    """
    Calcola la centralità di intermediazione (Betweenness Centrality) e restituisce i nodi
    con i punteggi di centralità più elevati.

    :param limit: Numero massimo di nodi da restituire (default 10)
    :return: Pandas DataFrame con i nodi e i loro punteggi di centralità
    """
    query = f"""
    CALL gds.betweenness.stream('{self.graph_name}')
    YIELD nodeId, score
    MATCH (n) WHERE id(n) = nodeId
    RETURN n.elementId AS id, n.ClassName AS class, score AS centrality
    ORDER BY score DESC
    LIMIT {limit};
    """

    with self.driver.session() as session:
        result = session.run(query)
        # Restituisci i risultati come un DataFrame
        return pd.DataFrame([dict(record) for record in result])
```

```
Received notification from DBMS server: {severity: WARNING} {code: Ne
     id                                class  centrality
0  None                        IfcOpenShell     14119.0
1  None           IfcFaceBasedSurfaceModel     12108.0
2  None             IfcShapeRepresentation      8094.0
3  None         IfcProductDefinitionShape      6072.0
4  None                           IfcSite      4058.0
5  None                 IfcLocalPlacement      1600.0
6  None                 IfcLocalPlacement      1057.0
7  None  IfcGeometricRepresentationContext       855.0
8  None               IfcRepresentationMap       825.0
9  None               IfcRepresentationMap       825.0
Received notification from DBMS server: {severity: WARNING} {code: Ne
Data esportati in ../output/centrality_results.csv
```

Achieved Results



class	centrality
"IfcOpenShell"	14118.99999
"IfcFaceBasedSurfaceModel"	12107.99999
"IfcShapeRepresentation"	8093.999999
"IfcProductDefinitionShape"	6071.999999
"IfcSite"	4057.999999
"IfcLocalPlacement"	1600.0
"IfcLocalPlacement"	1057.0
"IfcGeometricRepresentationContext"	855.0
"IfcRepresentationMap"	825.0

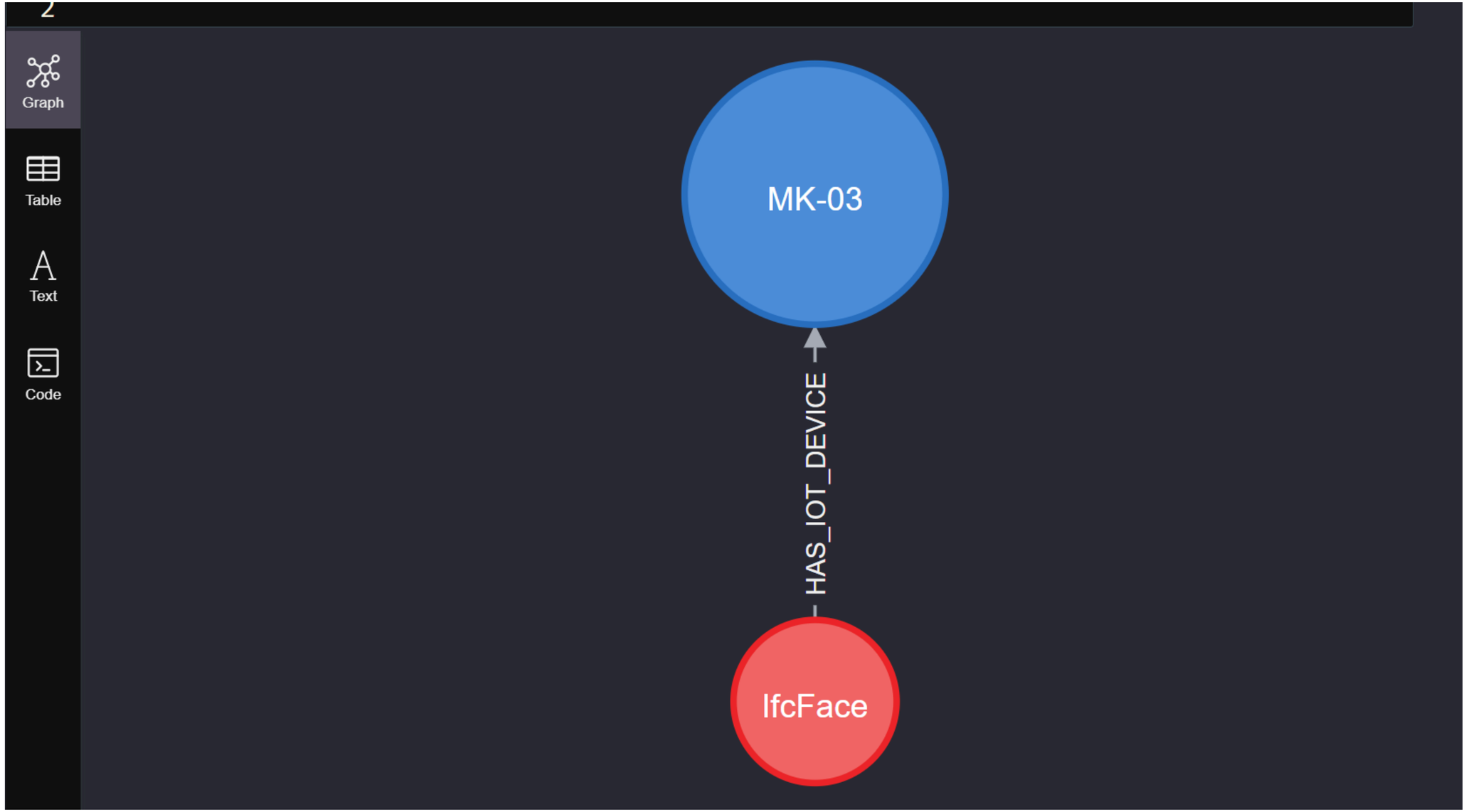
Achieved Results

Dynamic addition of a custom IoT sensor.

```python
def add_iot_to_ifc_node(graph, ifc_file_path, target_node_id, iot_device):
    """
    Aggiunge un dispositivo IoT a un nodo IfcNode nel grafo Neo4j.

    :param graph: Connessione al database Neo4j
    :param ifc_file_path: Percorso del file IFC (non utilizzato nel codice corrente)
    :param target_node_id: ID del nodo IfcNode a cui collegare il dispositivo IoT
    :param iot_device: Oggetto IoTDevice da aggiungere al nodo IfcNode
    """
    print(f"Lettura file IFC: {ifc_file_path}")
    f = ifcopenshell.open(ifc_file_path)

    print(f"Verifica nodo IfcNode con ID: {target_node_id} nel grafo")
    node_exists = graph.evaluate("MATCH (n:IfcNode {nid: $nid}) RETURN n", nid=target_node_id)

    if not node_exists:
        print(f"ERRORE: Il nodo IfcNode con ID {target_node_id} non esiste in Neo4j.")
        return  # Esce se il nodo non esiste

    # Creazione del nodo IoTDevice
    iot_node = iot_device.create_node(graph)

    print(f"Collegamento del dispositivo IoT {iot_device.device_id} al nodo IfcNode {target_nc

    # Crea la relazione tra IfcNode e IoTDevice
    query = """
    MATCH (n:IfcNode {nid: $node_id}), (iot:IoTDevice {device_id: $device_id})
    CREATE (n)-[:HAS_IOT_DEVICE]->(iot)
    """
    graph.run(query, node_id=target_node_id, device_id=iot_device.device_id)

    print(f"✅ Dispositivo IoT {iot_device.device_id} collegato con successo a IfcNode {target_node_id}!")
```

```
C:\Users\marin\UNIVERSITÁ\TBDM\IFC-Neo4j-converter\venv\Script
Lettura file IFC: ../ifc_files/IfcOpenHouse_original.ifc
Verifica nodo IfcNode con ID: 2319 nel grafo
Creazione del nodo IoTDevice con ID: MK-03
Collegamento del dispositivo IoT MK-03 al nodo IfcNode 2319
✅ Dispositivo IoT MK-03 collegato con successo a IfcNode 2319

Process finished with exit code 0
```

Achieved Results



Achieved Results

An export feature for saving or sharing the graph.

```
# 2856=IFCCARTESIANPOINT(840.0,5.0);
# 2851=IFCCARTESIANPOINT(-840.0,5.0);
# 2852=IFCDIRECTION(0.0,0.0,1.0);
# 2853=IFCDIRECTION(1.0,0.0,0.0);
# 2854=IFCDIRECTION(0.0,0.0,1.0);
# 2855=IFCCARTESIANPOINT(0.0,0.0);
# 2856=IFCELEMENT($,$,'IfcAxis2Placement3D');
# 2857=IFCPOLYLINE();
# 2858=IFCELEMENT($,$,'IfcArbitraryClosedProfileDef');
# 2859=IFCEXTRUDEDAREASOLID();
# 2860=IFCDIRECTION(1.0,0.0,0.0);
# 2861=IFCDIRECTION(0.0,0.0,1.0);
# 2862=IFCCARTESIANPOINT(930.0,45.0);
# 2863=IFCELEMENT($,$,'IfcAxis2Placement3D');
# 2864=IFCELEMENT($,$,'IfcLocalPlacement');
# 2865=IFCELEMENT($,$,'IfcPlate');
# 2866=IFCELEMENT($,$,'IfcColourRgb');
# 2867=IFCELEMENT($,$,'IfcSurfaceStyleRendering');
# 2868=IFCELEMENT($,$,'IfcSurfaceStyle');
# 2869=IFCELEMENT($,$,'IfcPresentationStyleAssignment');
# 2870=IFCELEMENT($,$,'IfcStyledItem');
# 2871=IFCELEMENT($,$,'IfcRelAggregates');
# REL_2319_MK-03=IFCRELASSOCIATES($,# 2319,# MK-03);
ENDSEC;
END-ISO-10303-21;
```

Future Improvements

- **graphical user interface (GUI)**
- **real-time synchronization** between IFC files and the graph database.
- Integration with other **BIM software** (such as Revit or Navisworks).
- **machine learning capabilities** for predictive insights.
- Improving **scalability**

Demo application

https://github.com/Diego-m4i/TBDMProject

http://localhost:7474/browser/

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Thanks for your attention

Diego Marinangeli