PROJECT DIGITALIZATION

Working Group 4 – Building an ESG Knowledge Graph

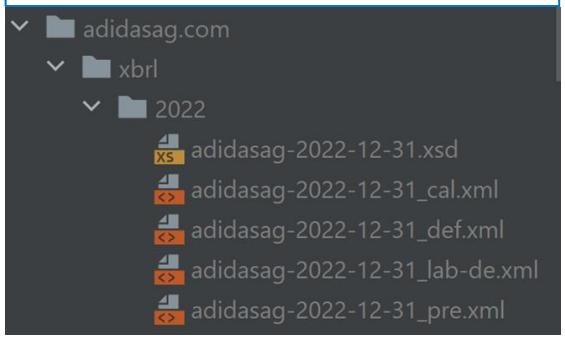
CONTENT

1. Extract data from XBRL
2. Ontologies
3. Knowledge Graph Construction
4. Add data to Knowledge Graph
   a. External data from wikidata and dbpedia
   b. Text embeddings
5. Knowledge Graph Bot
6. Knowledge Graph Queries

1. EXTRACT DATA FROM XBRL

ESRS: XBRL Delivery Requirement

ESEF Taxonomy Schema



Instance Document

1. extract and calculate:

JSON

Extract data from XBRL into standardized JSON-Files

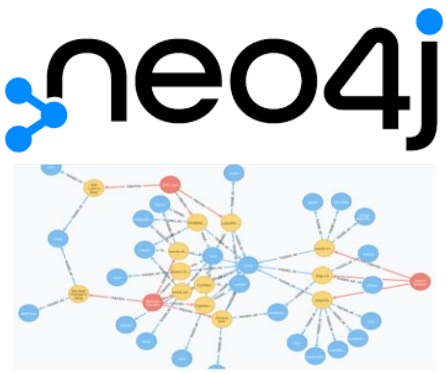
1. EXTRACT DATA FROM XBRL

JSON


```
{
  "facts": {
    "f0": {
      "dimensions": {
        "unit": "iso4217:EUR",
        "concept": "CashAndCashEquivalents",
        "entity": "549300JSX0Z4CW0V5023",
        "period": "2022-12-31"
      },
      "decimals": -6,
      "value": 798000000.0
    },
    "f1": {
      "dimensions": {
        "unit": "iso4217:EUR",
        "concept": "CashAndCashEquivalents",
```


2. populate

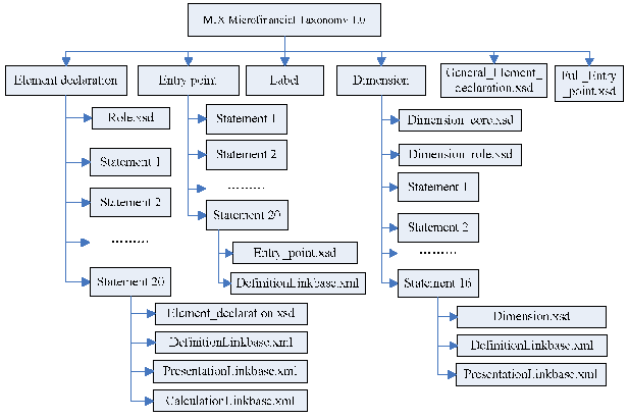
Knowledge Graph



No ESG data available yet – we used sample data to populate the Knowledge Graph

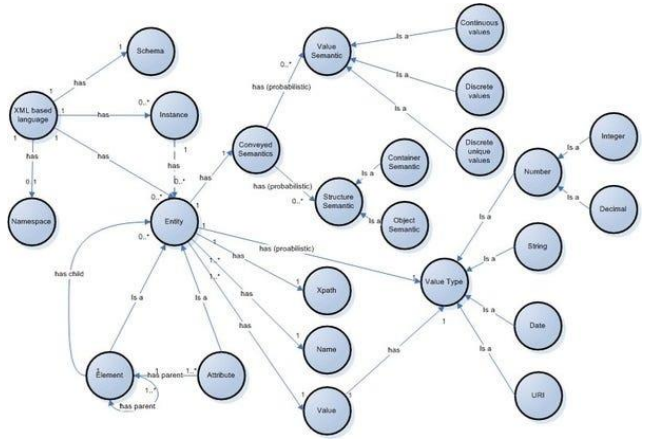
2. ONTOLOGIES

ESRS Taxonomy Schema



derive

Ontology / Knowledge Graph



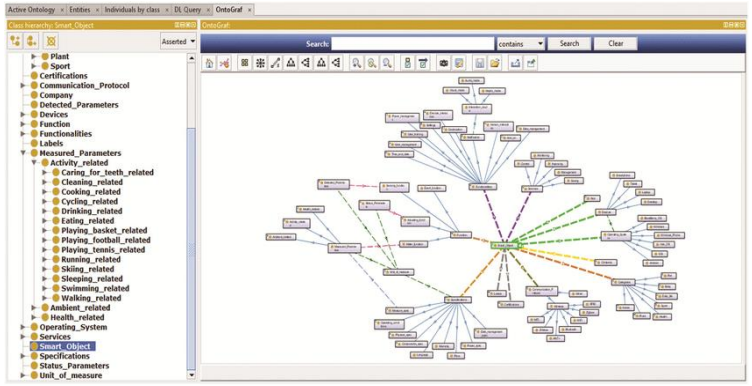
- Hierarchy
- Concrete

- Semantic Meaning
- Relationships

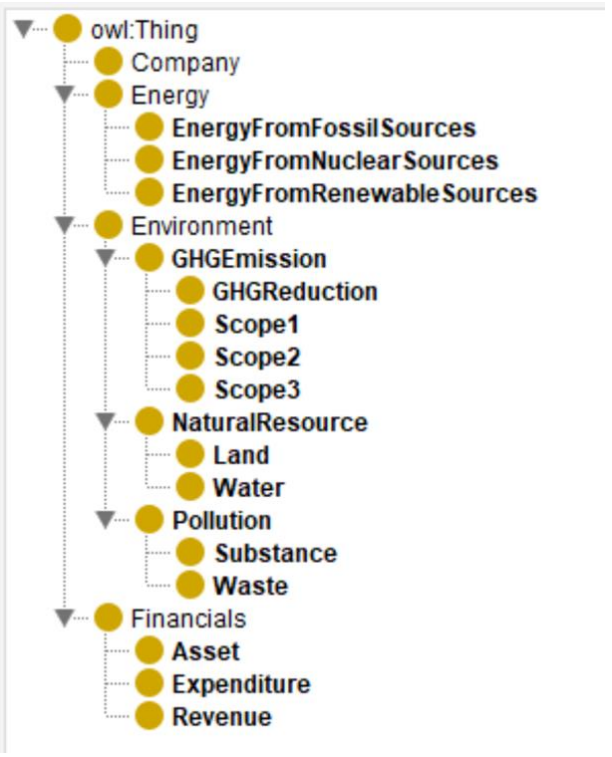
Derive Ontology based on ESRS Taxonomy

2. ONTOLOGIES

protégé



create



Created ontology for 21 exemplary data points with 16 Node labels

2. ONTOLOGIES

#	ParentNode	Node	Original Variable	Label	Unit
1	Energy	EnergyFromFossilSources	Total energy consumption from fossil sources	TotalEnergyConsumptionFromFossilSources	MWh
2	Energy	EnergyFromNuclearSources	Total energy consumption from nuclear sources	TotalEnergyConsumptionFromNuclearSources	MWh
3	Energy	EnergyFromRenewableSources	Total energy consumption from renewable sources	TotalEnergyConsumptionFromRenewableSources	MWh
4	Financials	Asset	Assets at material physical risk before considering climate change adaptation actions	AssetsAtMaterialPhysicalRiskBeforeClimateChangeAdaptationActions	EUR
5	Financials	Asset	Assets at material transition risk before considering climate mitigation actions	AssetsAtMaterialTransitionRiskBeforeClimateMitigationActions	EUR
6	Financials	Expenditure	Financial resources allocated to action plan (OpEx)	FinancialResourcesAllocatedToActionPlanOpEx	EUR
7	Financials	Expenditure	Financial resources allocated to action plan (CapEx)	FinancialResourcesAllocatedToActionPlanCapEx	EUR
8	Financials	Revenue	Net revenue used to calculate GHG intensity	NetRevenueUsedToCalculateGHGIntensity	EUR
9	Financials	Revenue	Net revenue	NetRevenue	EUR
10	GHGEmission	GHGEmission	Total GHG emissions	TotalGHGEmissions	tonsCO2Eq
11	GHGEmission	Reduction	Absolute value of total Greenhouse gas emissions reduction	AbsoluteValueOfTotalGHGEmissionsReduction	tonsCO2Eq
12	GHGEmission	Scope1	Gross Scope 1 greenhouse gas emissions	GrossScope1GHGEmissions	tonsCO2Eq
13	GHGEmission	Scope2	Gross location-based Scope 2 greenhouse gas emissions	GrossLocationBasedScope2GHGEmissions	tonsCO2Eq
14	GHGEmission	Scope2	Gross market-based Scope 2 greenhouse gas emissions	GrossMarketBasedScope2GHGEmissions	tonsCO2Eq
15	GHGEmission	Scope3	Gross Scope 3 greenhouse gas emissions	GrossScope3GHGEmissions	tonsCO2Eq
16	NaturalResource	Water	Total water consumption	TotalWaterConsumption	cubicmeter
17	NaturalResource	Land	Total use of land area	TotalUseOfLandArea	hectares
18	Pollution	Substance	Total amount of substances of concern that are generated or used during production or that are procured	TotalAmountOfSubstancesOfConcernGenerated	tons
19	Pollution	Waste	Emissions to air by pollutant	EmissionsToAirByPollutant	tons
20	Pollution	Waste	Emissions to soil by pollutant [+ by sectors/Geographical Area/Type of source/Site location]	EmissionsToSoilByPollutant	tons
21	Pollution	Waste	Emissions to water by polllutant [+ by sectors/Geographical Area/Type of source/Site location]	EmissionsToWaterByPolllutant	tons

16 NODE LABELS: SUBORDINATE POSSIBLY ALL DATAPOINTS

DATA FROM ALL ESRS-AREAS:

ESRS_E1: **Climate Change**

ESRS_E2: **Pollution**

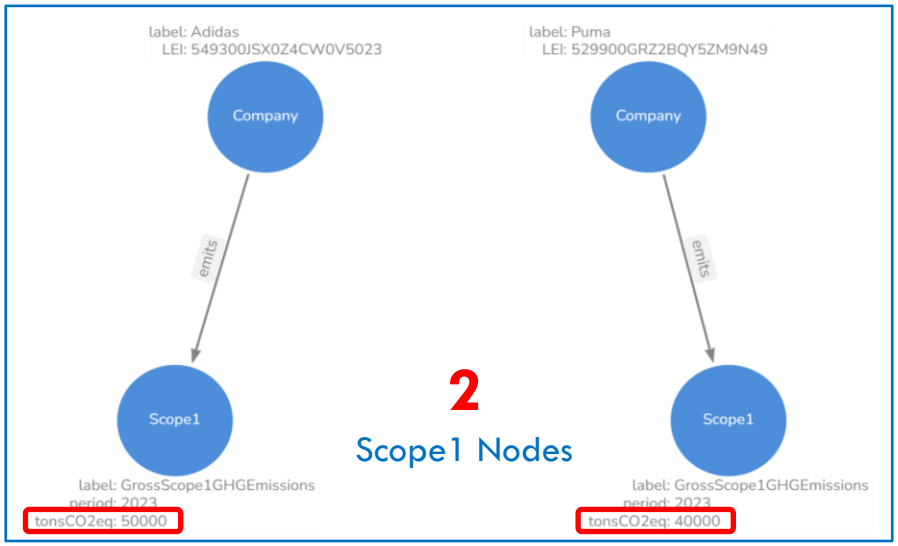
ESRS_E3: **Water and Marine Resources**

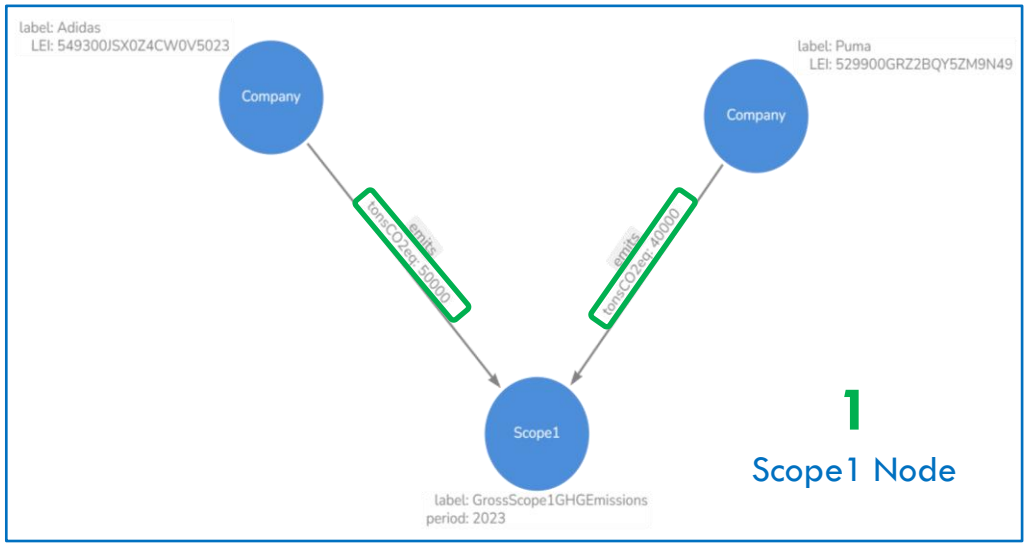
ESRS_E4: **Biodiversity and Ecosystems**

ESRS_E5: **Resource Use and Circular Economy**

16 Node labels capable to subordinate ALL (>21) data points. Data from all E-Areas (E1-E5).

2. ONTOLOGIES

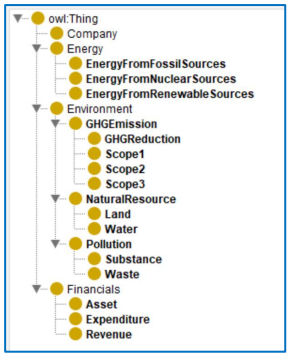




Data point values stored in RELATIONSHIP, not in NODE. Saves Nodes and memory.

3. KNOWLEDGE GRAPH CONSTRUCTION

Ontology



unique_node_keys

```
{"Company": ["LEI"],
 "Waste": ["period", "label"],
 "Substance": ["period", "label"],
 "EnergyFromNuclearSources": ["period", "label"],
 "EnergyFromFossilSources": ["period", "label"],
 "EnergyFromRenewableSources": ["period", "label"],
 "GHGEmission": ["period", "label"],
 "Scope1": ["period", "label"],
 "Scope2": ["period", "label"],
 "Scope3": ["period", "label"],
 "GHGReduction": ["period", "label"],
 "Land": ["period", "label"],
 "Water": ["period", "label"],
 "Asset": ["period", "label"],
 "Expenditure": ["period", "label"],
 "Revenue": ["period", "label"],
}
```

node_val_props

```
{"Waste": "tons",
 "Substance": "tons",
 "EnergyFromNuclearSources": "MWh",
 "EnergyFromFossilSources": "MWh",
 "EnergyFromRenewableSources": "MWh",
 "GHGEmission": "tonsCO2Eq",
 "Scope1": "tonsCO2Eq",
 "Scope2": "tonsCO2Eq",
 "Scope3": "tonsCO2Eq",
 "GHGReduction": "tonsCO2Eq",
 "Land": "hectares",
 "Water": "cubicmetres",
 "Asset": "EUR",
 "Revenue": "EUR",
 "Expenditure": "EUR"
}
```

1

node_query_templates

```
WITH $node_data AS node_data
MERGE (n:Asset { period: node_data['Asset']['period'],
                 label: node_data['Asset']['label'] } )
RETURN count(*) as total
```

relation_query_templates

```
WITH $rel_data AS rel_data
MATCH (source:Company { LEI: rel_data["Company_disposes_Waste"]["source"]["Company"]["LEI"] } )
MATCH (target:Waste { period: rel_data["Company_disposes_Waste"]["target"]["Waste"]["period"],
                      label: rel_data["Company_disposes_Waste"]["target"]["Waste"]["label"] } )
MERGE (source)-[r:disposes { tons: rel_data["Company_disposes_Waste"]["target"]["Waste"]["tons"] }]->(target)
RETURN count(*) as total
```

constraint_query_templates

```
CREATE CONSTRAINT constraint_for_node_Waste IF NOT EXISTS
FOR (node:Waste) REQUIRE (node.period, node.label) IS UNIQUE;
```

namespace_query_templates

```
CALL n10s.nsprefixes.add('rso','http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#Scope2', 'Scope2');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#hectares', 'hectares');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#Scope3', 'Scope3');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#Company', 'Company');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#Waste', 'Waste');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#spends', 'spends');
CALL n10s.mapping.add('http://www.semanticweb.org/rainergo/ontologies/2023/10/Ontology4#label', 'label');
```

2

JSON-Data

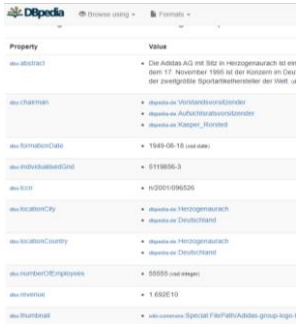
```
{
  "facts": {
    "f0": {
      "dimensions": {
        "unit": "iso4217:EUR",
        "concept": "CashAndCashEquivalents",
        "entity": "549300JSX0Z4CW0V5023",
        "period": "2022-12-31"
      },
      "decimals": -6,
      "value": 798000000.0
    },
    "f1": {
      "dimensions": {
        "unit": "iso4217:EUR",
        "concept": "CashAndCashEquivalents",
```

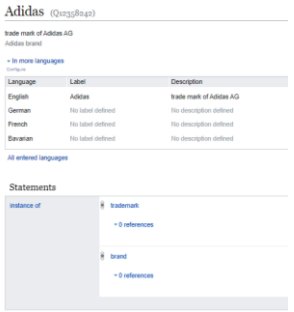
3

neo4j

Ontology and inputs create query-templates that are used to import the JSON-data into NEO4J

4. ADD DATA TO KNOWLEDGE GRAPH



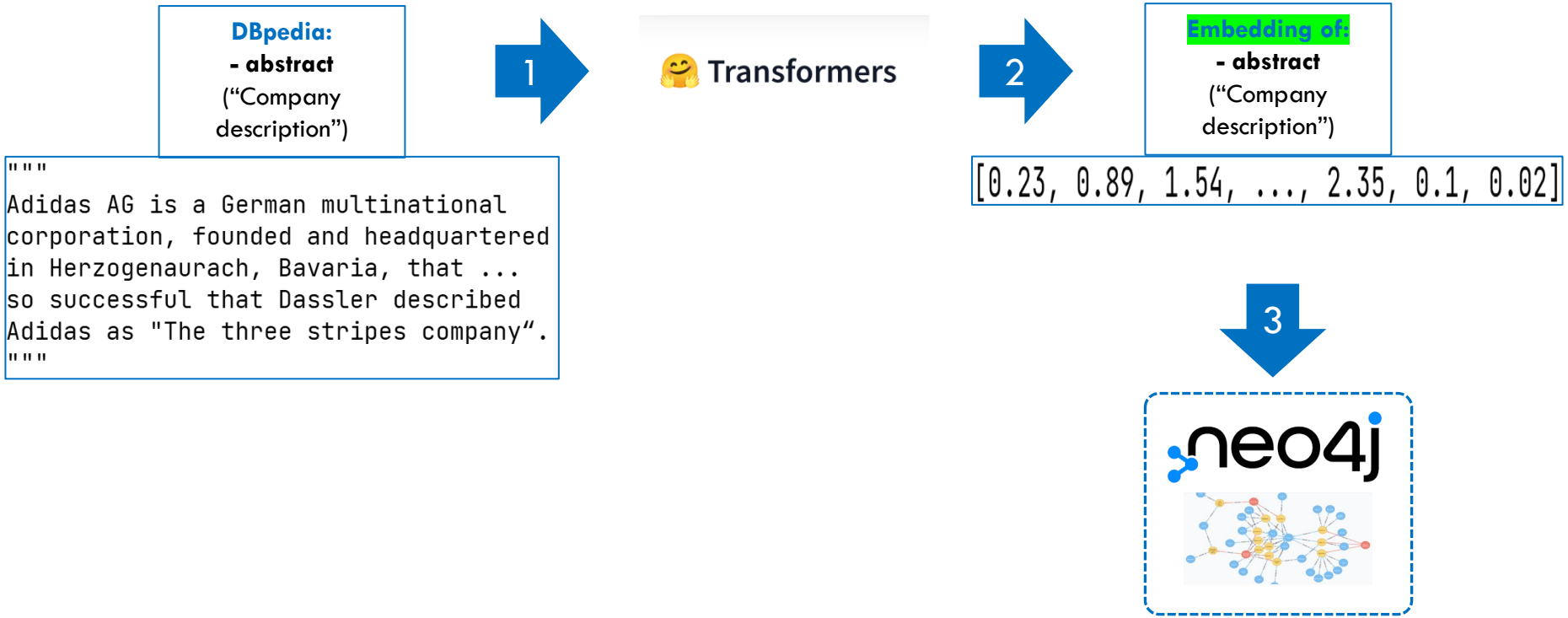


DBpedia:
- abstract
("Company description")

wikidata:
- industries
- country
- ISIN

External data from wikidata and DBpedia loaded into NEO4J via SPARQL requests over internet

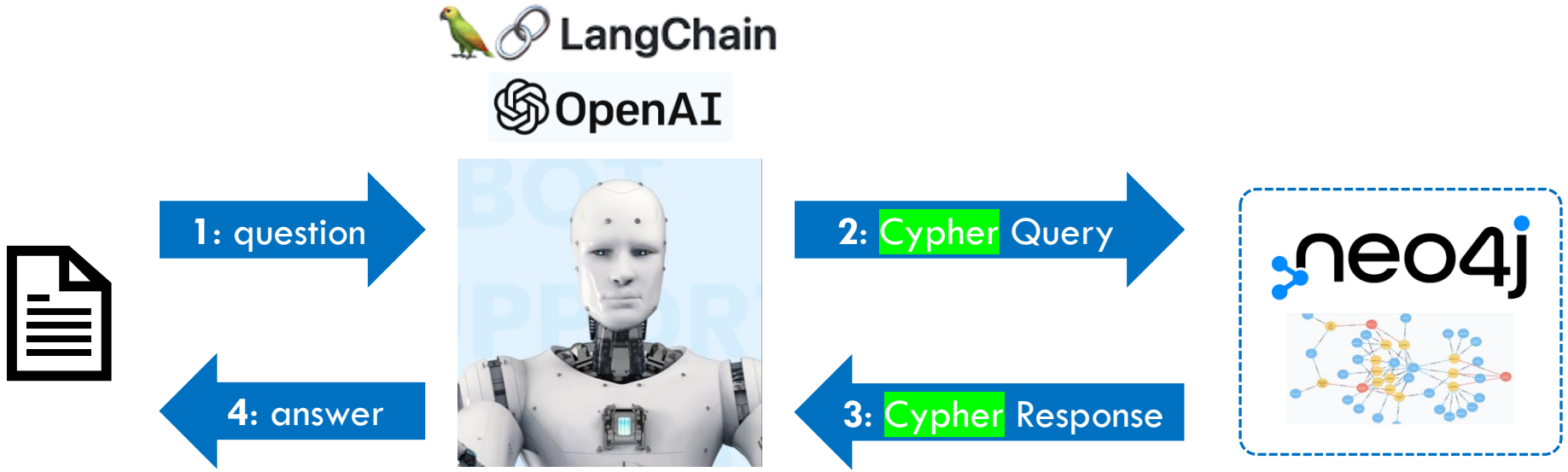
4. ADD DATA TO KNOWLEDGE GRAPH



Add embedding of text to Knowledge Graph Node ("Company") as property to later do similarity search


LIVE DEMO 1:
Create Knowledge Graph with data in NEO4J

5. KNOWLEDGE GRAPH BOT



Send text question to Knowledge Graph Bot to receive text answer

6. KNOWLEDGE GRAPH QUERIES

Parameterizable Functions:

```python
def get_statistics_by_esrs_data(self,
                                esrs: ESRS,
                                stat: Stats,
                                periods: list or None = None,
                                by_period: bool = False,
                                return_df: bool = False)

def get_statistics_by_company(self,
                              esrs: ESRS,
                              stat: Stats,
                              periods: list or None = None,
                              return_df: bool = False)

def get_ratio_of_two_esrs(self,
                          esrs_numerator: ESRS,
                          esrs_denominator: ESRS,
                          comp: Company,
                          stat: Stats,
                          periods: list or None = None,
                          return_df: bool = False)

def get_difference_of_two_periods(self,
                                  esrs: ESRS,
                                  comp: Company,
                                  stat: Stats,
                                  periods: list or None = None,
                                  return_df: bool = False)
```

1

Parameters:

esrs:	An ESRS-Enum, see project's README.md. Must always be provided.
periods:	Must be a list. Can be ['2022', '2023'] for multiple years or ['2022'] for a single year.
company:	An Company-Enum. If set to "None", the result is shown for all comapnies in the KG.
stat:	A Stats-Enum ("Statistics"). If set to "None", indivdual values will be shown.
return_df:	If set to "True", a pandas "DataFrame" will be returned, else a NEO4J "Record"-object.

2

```
Question: Which company had the most "EmissionsToAirByPollutant" in ['2023', '2022'] ?
Question: In which year did Adidas have the highest EmissionsToAirByPollutant and how much was it?
Question: What was the SUM of "EmissionsToAirByPollutant" over the periods ['2023', '2022'] by company?
Question: What was the (total) SUM of "EmissionsToAirByPollutant" over the periods ['2023', '2022'] ?
Question: What was the ratio between EmissionsToAirByPollutant to NetRevenue for company "Adidas" in ['2023', '2022'] ?
Question: What was the ratio between the SUM of EmissionsToAirByPollutant to SUM of NetRevenue for all companies in ['2023'
Question: What company had the highest ratio of EmissionsToAirByPollutant to NetRevenue in the ['2023', '2022'] ?
Question: How much did "EmissionsToAirByPollutant" change over the periods ['2023', '2022'] for company Adidas ?
Question: How much did "EmissionsToAirByPollutant" change over the periods ['2023', '2022'] by company ?
Question: How much did the "SUM" for "EmissionsToAirByPollutant" change over the periods ['2023', '2022'] ?
Question: The company in which "Industries" had the highest "EmissionsToAirByPollutant" in the periods ['2023', '2022'] ?
Question: Which "Industries" had the highest "SUM" of "EmissionsToAirByPollutant" in the periods ['2023', '2022'] ?
Question: Which "Country" had the highest "SUM" of "EmissionsToAirByPollutant" in the periods ['2023', '2022'] ?
```

Parameterized functions allow for a wide range of different questions.


LIVE DEMO 2:
Query Knowledge Graph


Thank you
for your attention !