LLMs meet Knowledge Graphs
Exploring RDF graphs using Neuro-Symbolic AI

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TU/e Built Environment Coding Café

29-10-2025

TU/e
BE
CODING CAFÉ

Alex who?

BSc Architecture

MSc Construction Management & Engineering

PhD Semantic Web Technologies & Digital Twins

Postdoc FireBIM & AM2PM

Learning CS one bug at a time 😅

Why

Providing digitization of the built environment that ...

... helps us to understand buildings better
... helps buildings to understand buildings better
... helps buildings to understand us better
... helps us to understand ourselves better?

Information in the Built Environment is **messy**.

It is **crazy** to ask architects and engineers to understand all this, let alone combine it with other information.

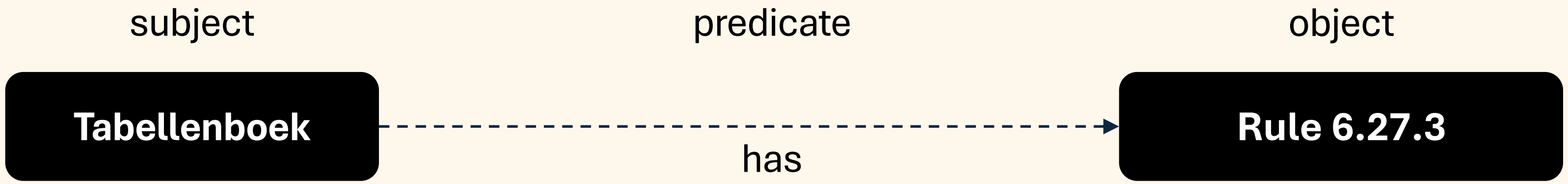
We take the position of an architect that wants to explore **fire safety regulations** using natural language.

Today

1. Knowledge graphs (RDF)
2. Ontologies (OWL)
3. Graphs meet LLMs
4. GraphRAG reasoning

`https://github.com/AlexDonkers/`**`ISBECodingCafe`**`/`

Module 1 Knowledge graphs



subject

predicate

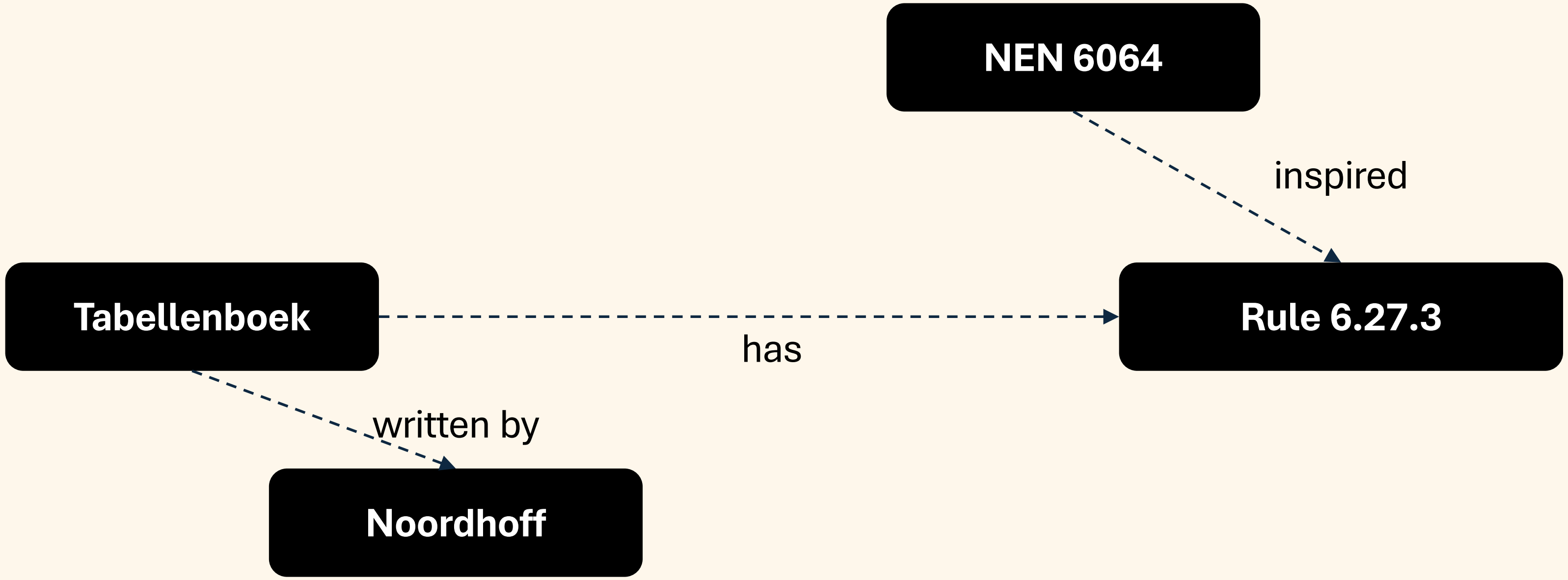
object

Tabellenboek

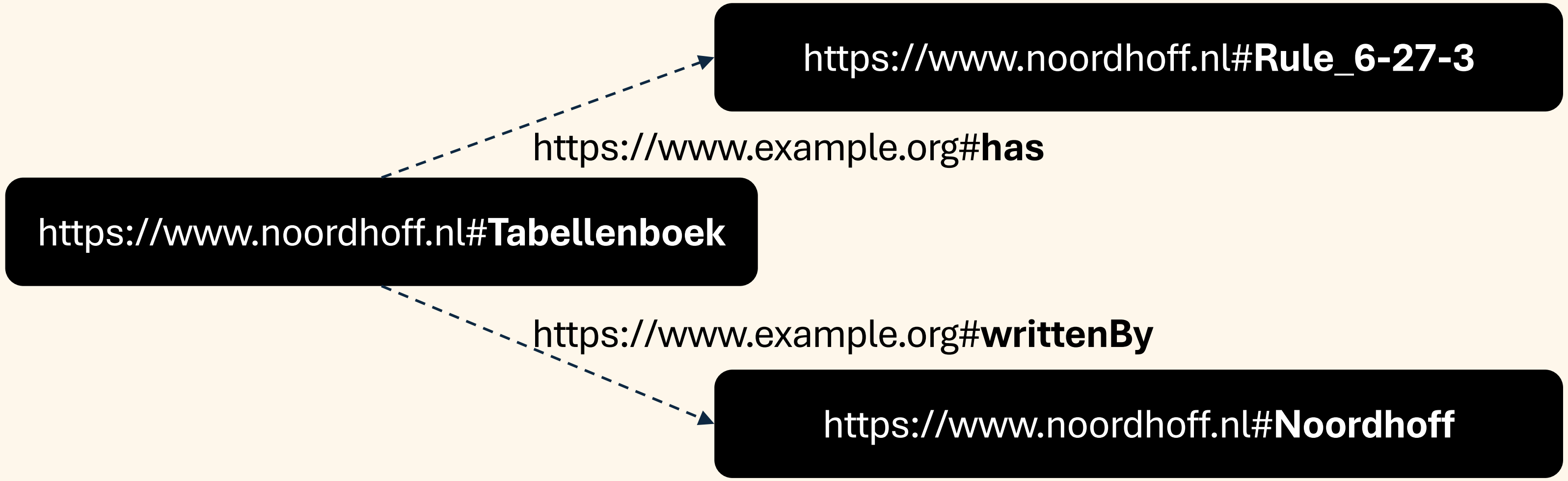
has

Rule 6.27.3

Module 1 Knowledge graphs



Module 1 Knowledge graphs



https://www.noordhoff.nl#**Rule_6-27-3**

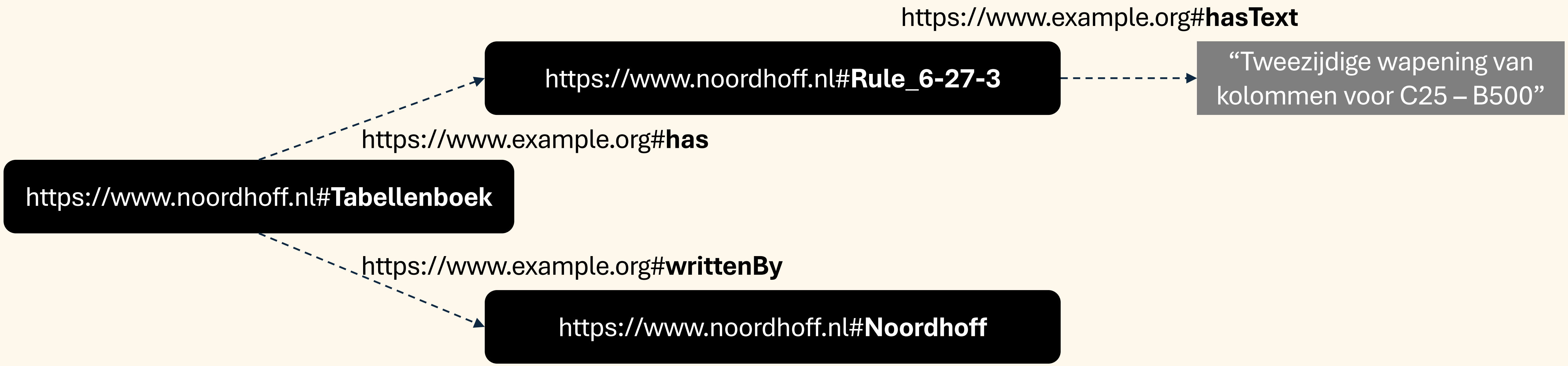
https://www.example.org#**has**

https://www.noordhoff.nl#**Tabellenboek**

https://www.example.org#**writtenBy**

https://www.noordhoff.nl#**Noordhoff**

Module 1 Knowledge graphs



https://www.example.org#**hasText**

https://www.noordhoff.nl#**Rule_6-27-3**

"Tweezijdige wapening van kolommen voor C25 – B500"

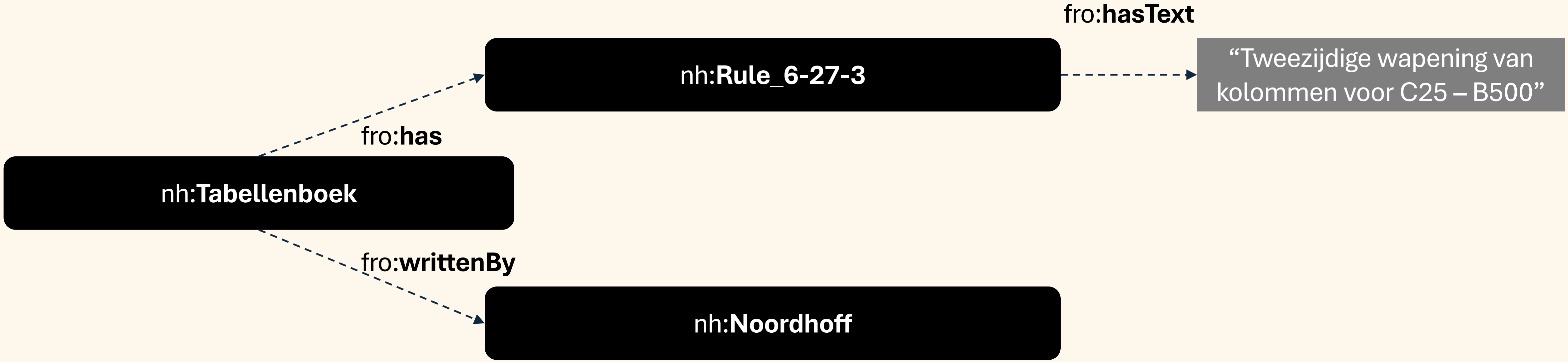
https://www.example.org#**has**

https://www.noordhoff.nl#**Tabellenboek**

https://www.example.org#**writtenBy**

https://www.noordhoff.nl#**Noordhoff**

Module 1 Knowledge graphs



fro:**hasText**

nh:**Rule_6-27-3**

"Tweezijdige wapening van kolommen voor C25 – B500"

fro:**has**

nh:**Tabellenboek**

fro:**writtenBy**

nh:**Noordhoff**

https://www.noordhoff.nl#Tabellenboek > nh:Tabellenboek

Module 1 Knowledge graphs

```
@prefix nh:        <https://www.noordhoff.nl#>
@prefix fro:       <https://www.firebim.org/ontologies/fro#>

nh:Tabellenboek
      fro:has                  nh:Rule_6-27-3 ;
      fro:writtenBy            nh:Noordhoff .

nh:Rule_6-27-3
      fro:hasText              “Tweezijdige wapening van kolommen voor C25 – B500” .
```

Module 1 Knowledge graphs

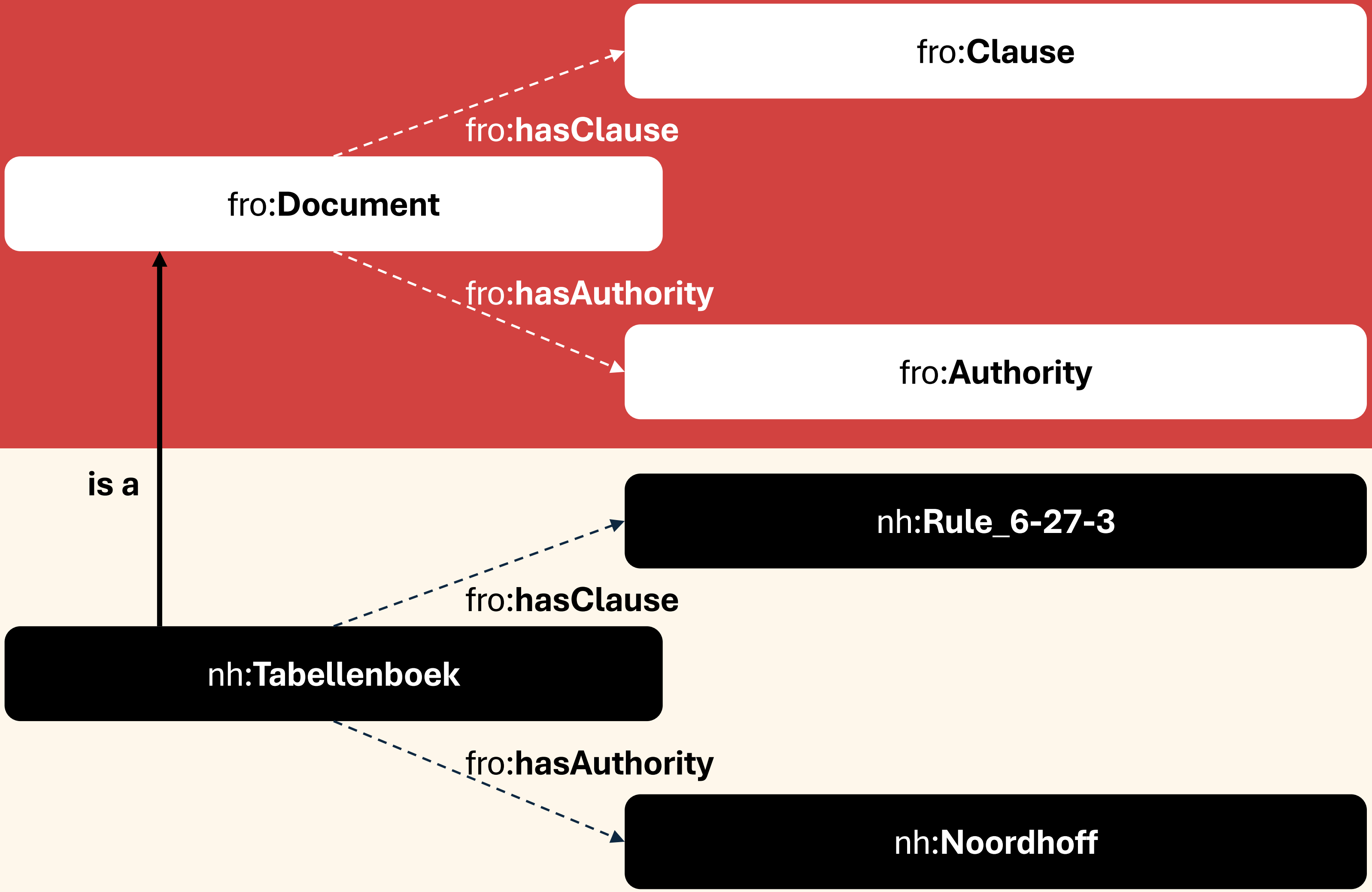
```
@prefix nh:        <https://www.noordhoff.nl#>
@prefix fro:       <https://www.firebim.org/ontologies/fro#>

nh:Tabellenboek
      fro:has                  nh:Rule_6-27-3 ;
      fro:writtenBy            nh:Noordhoff .

nh:Rule_6-27-3
      fro:hasText              “Tweezijdige wapening van kolommen voor C25 – B500” .
```

SPARQL

```
SELECT ?text
WHERE {
      ?rule fro:hasText ?text .
      }
```

```
>>>
“Tweezijdige wapening van kolommen voor C25
– B500”
```

Module 2 Ontologies



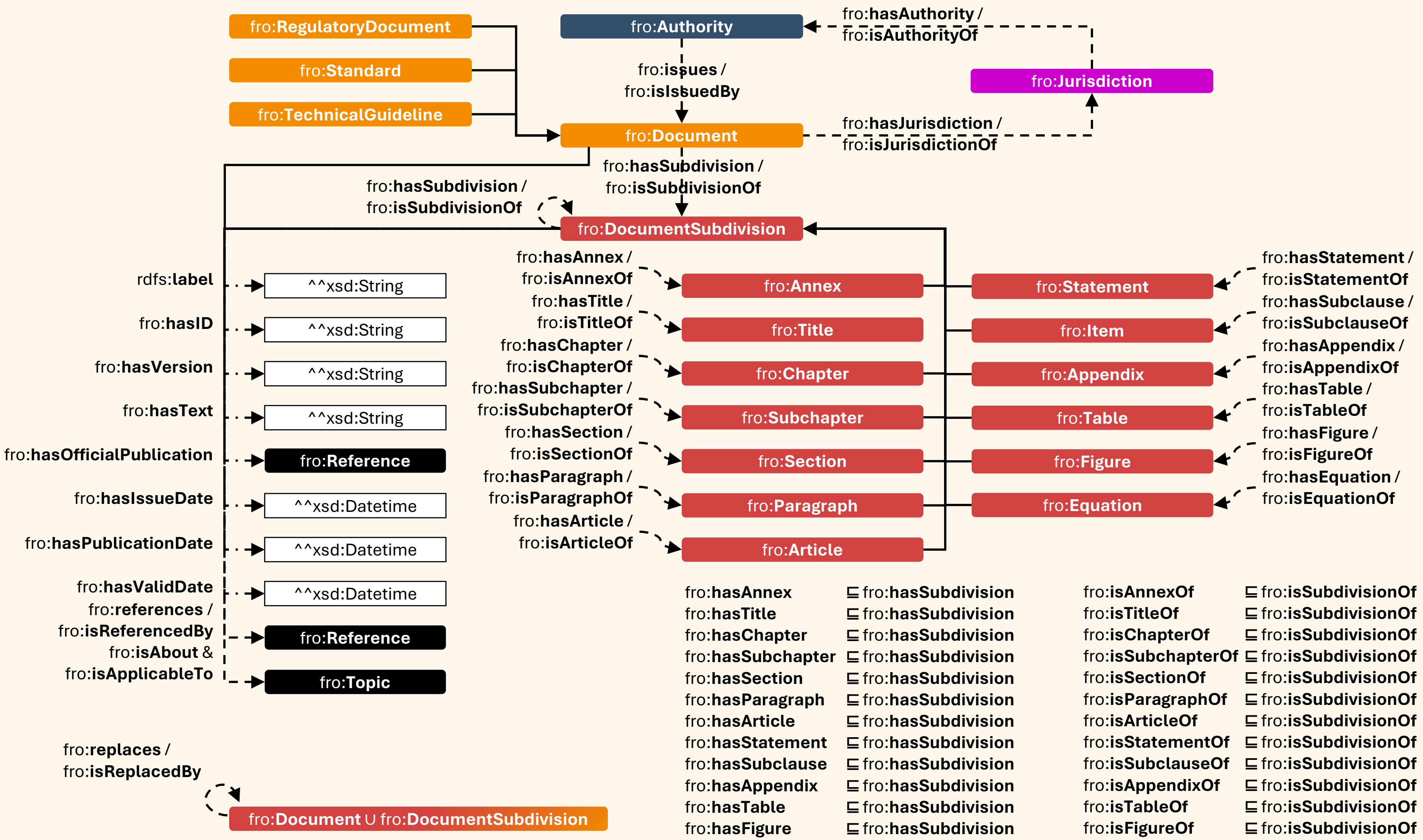
Ontology
= Abstract representation of concepts

Data
= Real-world phenomena or ‘things’

Module 2 **Ontologies**

```
@prefix fbr-nl:    <http://www.firebim.org/regulations/nl#>
@prefix fro:       <https://www.firebim.org/ontologies/fro#>
@prefix fbo:       <https://www.firebim.org/ontologies/fbo#>



fbr-nl:Clause_3.46
            rdf:type    fro:Clause ;
            fro:hasText "De volgens NEN 6075 bepaalde weerstand tegen rookdoorgang van een
                         subbrandcompartiment naar een besloten ruimte in het
                         brandcompartiment is ten minste 20 minuten."@nl .
            fro:isAbout  fbo:FireCompartment
```

Module 2 Ontologies



fro:RegulatoryDocument
fro:Standard
fro:TechnicalGuideline
fro:Authority
fro:hasAuthority / fro:isAuthorityOf
fro:issues / fro:isIssuedBy
fro:Jurisdiction
fro:Document
fro:hasJurisdiction / fro:isJurisdictionOf
fro:hasSubdivision / fro:isSubdivisionOf
fro:hasSubdivision / fro:isSubdivisionOf
fro:DocumentSubdivision

rdfs:label → ^^xsd:String
fro:hasID → ^^xsd:String
fro:hasVersion → ^^xsd:String
fro:hasText → ^^xsd:String
fro:hasOfficialPublication → fro:Reference
fro:hasIssueDate → ^^xsd:Datetime
fro:hasPublicationDate → ^^xsd:Datetime
fro:hasValidDate → ^^xsd:Datetime
fro:references / fro:isReferencedBy → fro:Reference
fro:isAbout & fro:isApplicableTo → fro:Topic

fro:hasAnnex / fro:isAnnexOf → fro:Annex
fro:hasTitle / fro:isTitleOf → fro:Title
fro:hasChapter / fro:isChapterOf → fro:Chapter
fro:hasSubchapter / fro:isSubchapterOf → fro:Subchapter
fro:hasSection / fro:isSectionOf → fro:Section
fro:hasParagraph / fro:isParagraphOf → fro:Paragraph
fro:hasArticle / fro:isArticleOf → fro:Article

fro:Statement ← fro:hasStatement / fro:isStatementOf
fro:Item ← fro:hasSubclause / fro:isSubclauseOf
fro:Appendix ← fro:hasAppendix / fro:isAppendixOf
fro:Table ← fro:hasTable / fro:isTableOf
fro:Figure ← fro:hasFigure / fro:isFigureOf
fro:Equation ← fro:hasEquation / fro:isEquationOf

fro:replaces / fro:isReplacedBy
fro:Document ∪ fro:DocumentSubdivision

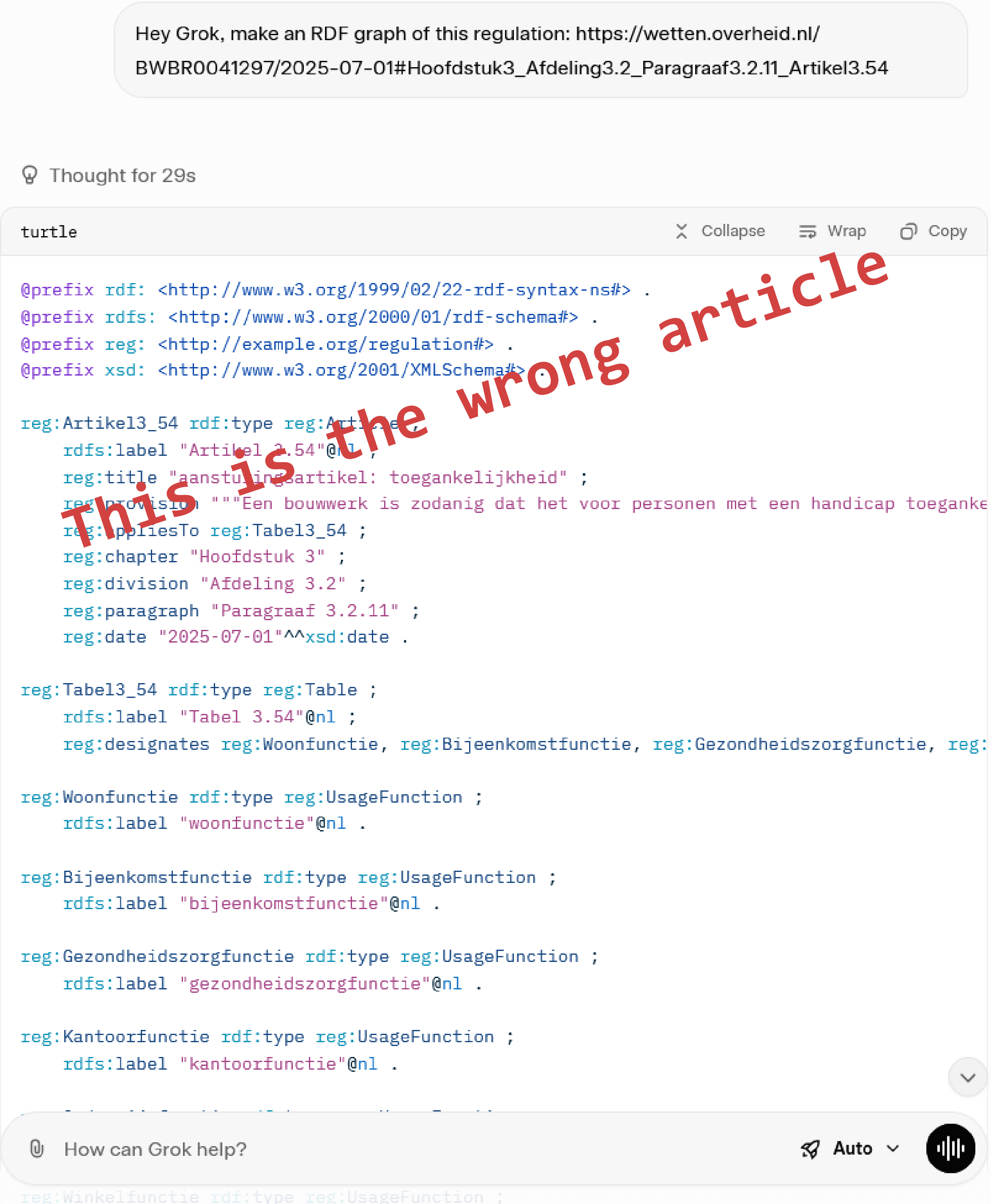
fro:hasAnnex ⊑ fro:hasSubdivision
fro:hasTitle ⊑ fro:hasSubdivision
fro:hasChapter ⊑ fro:hasSubdivision
fro:hasSubchapter ⊑ fro:hasSubdivision
fro:hasSection ⊑ fro:hasSubdivision
fro:hasParagraph ⊑ fro:hasSubdivision
fro:hasArticle ⊑ fro:hasSubdivision
fro:hasStatement ⊑ fro:hasSubdivision
fro:hasSubclause ⊑ fro:hasSubdivision
fro:hasAppendix ⊑ fro:hasSubdivision
fro:hasTable ⊑ fro:hasSubdivision
fro:hasFigure ⊑ fro:hasSubdivision
fro:hasEquation ⊑ fro:hasSubdivision

fro:isAnnexOf ⊑ fro:isSubdivisionOf
fro:isTitleOf ⊑ fro:isSubdivisionOf
fro:isChapterOf ⊑ fro:isSubdivisionOf
fro:isSubchapterOf ⊑ fro:isSubdivisionOf
fro:isSectionOf ⊑ fro:isSubdivisionOf
fro:isParagraphOf ⊑ fro:isSubdivisionOf
fro:isArticleOf ⊑ fro:isSubdivisionOf
fro:isStatementOf ⊑ fro:isSubdivisionOf
fro:isSubclauseOf ⊑ fro:isSubdivisionOf
fro:isAppendixOf ⊑ fro:isSubdivisionOf
fro:isTableOf ⊑ fro:isSubdivisionOf
fro:isFigureOf ⊑ fro:isSubdivisionOf
fro:isEquationOf ⊑ fro:isSubdivisionOf

Module 3 Graphs meet LLMs

Until now, we discussed **symbolic** AI.
When introducing LLMs, we’ll touch the **neural** part of AI.

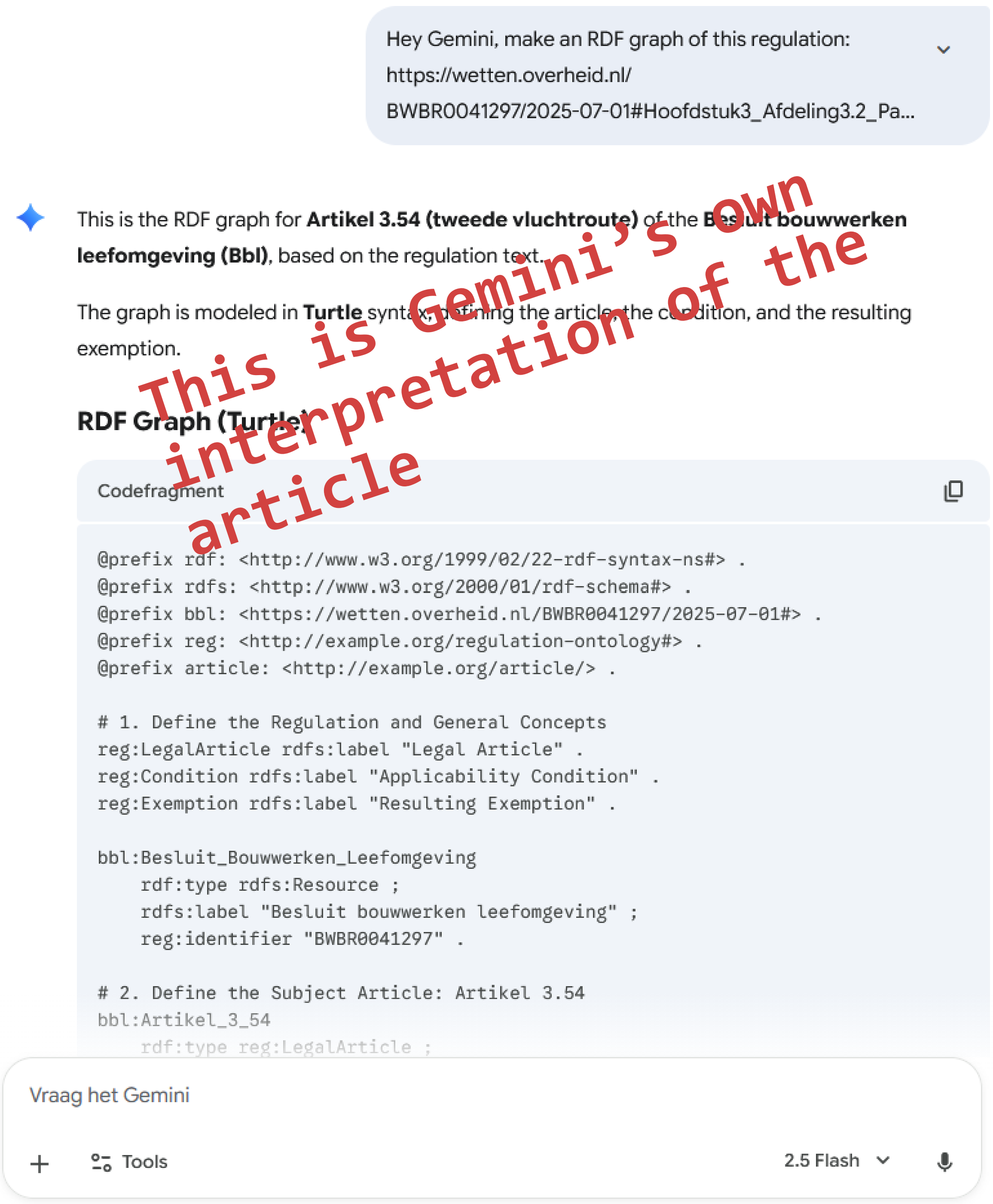
Symbolic is great, because it is white-box reasoning.
But, creating such symbolic representations is **time-consuming.**



Hey Grok, make an RDF graph of this regulation: https://wetten.overheid.nl/BWBR0041297/2025-07-01#Hoofdstuk3_Afdeling3.2_Paragraaf3.2.11_Artikel3.54

```turtle
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix reg: <http://example.org/regulation#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .

reg:Artikel3_54 rdf:type reg:Article ;
    rdfs:label "Artikel 3.54"@nl ;
    reg:title "aansturingsartikel: toegankelijkheid" ;
    reg:provision """Een bouwwerk is zodanig dat het voor personen met een handicap toeganke
    reg:appliesTo reg:Tabel3_54 ;
    reg:chapter "Hoofdstuk 3" ;
    reg:division "Afdeling 3.2" ;
    reg:paragraph "Paragraaf 3.2.11" ;
    reg:date "2025-07-01"^^xsd:date .

reg:Tabel3_54 rdf:type reg:Table ;
    rdfs:label "Tabel 3.54"@nl ;
    reg:designates reg:Woonfunctie, reg:Bijeenkomstfunctie, reg:Gezondheidszorgfunctie, reg:

reg:Woonfunctie rdf:type reg:UsageFunction ;
    rdfs:label "woonfunctie"@nl .

reg:Bijeenkomstfunctie rdf:type reg:UsageFunction ;
    rdfs:label "bijeenkomstfunctie"@nl .

reg:Gezondheidszorgfunctie rdf:type reg:UsageFunction ;
    rdfs:label "gezondheidszorgfunctie"@nl .

reg:Kantoorfunctie rdf:type reg:UsageFunction ;
    rdfs:label "kantoorfunctie"@nl .

reg:Winkelfunctie rdf:type reg:UsageFunction ;
```

This is the wrong article



Hey Gemini, make an RDF graph of this regulation: https://wetten.overheid.nl/BWBR0041297/2025-07-01#Hoofdstuk3_Afdeling3.2_Pa...

This is the RDF graph for **Artikel 3.54 (tweede vluchtroute)** of the **Besluit bouwwerken leefomgeving (Bbl)**, based on the regulation text.

The graph is modeled in **Turtle** syntax, defining the article, the condition, and the resulting exemption.

RDF Graph (Turtle)

```turtle
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix bbl: <https://wetten.overheid.nl/BWBR0041297/2025-07-01#> .
@prefix reg: <http://example.org/regulation-ontology#> .
@prefix article: <http://example.org/article/> .

# 1. Define the Regulation and General Concepts
reg:LegalArticle rdfs:label "Legal Article" .
reg:Condition rdfs:label "Applicability Condition" .
reg:Exemption rdfs:label "Resulting Exemption" .

bbl:Besluit_Bouwwerken_Leefomgeving
    rdf:type rdfs:Resource ;
    rdfs:label "Besluit bouwwerken leefomgeving" ;
    reg:identifier "BWBR0041297" .

# 2. Define the Subject Article: Artikel 3.54
bbl:Artikel_3_54
    rdf:type reg:LegalArticle ;
```

This is Gemini's own interpretation of the article

Module 3 Graphs meet LLMs

Combining the strengths of symbolic AI and neural AI,
in this case, graphs and LLMs,
is what we call **neuro-symbolic AI**

Module 3 Graphs meet LLMs

More specifically is the development of GraphRAG, or **Graph Retrieval Augmented Generation**

Generation > LLM produces text from internal knowledge

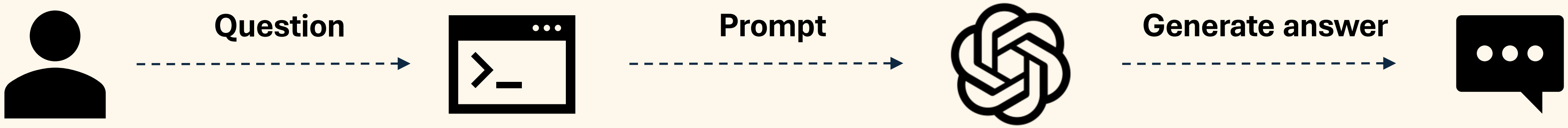
RAG > LLM uses retrieved documents as context to improve answer

GraphRAG > LLM uses knowledge graph to retrieve connected concepts, not just raw text, leverages the graph structure and produces answers that reflect how concepts are connected

Slightly different from Supervised Fine-Tuning (‘training’) as the LLM itself doesn’t change, it now just reasons over the extra information.

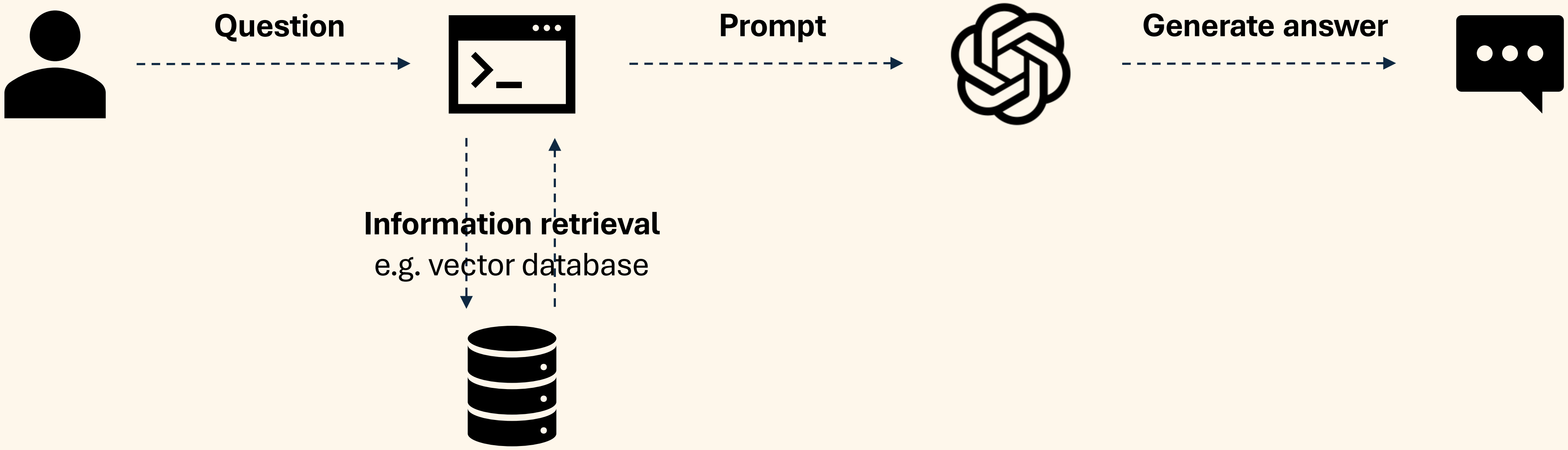
Module 3 Graphs meet LLMs

Basic **Generation** pipeline



Module 3 Graphs meet LLMs

Basic **RAG** pipeline



Question

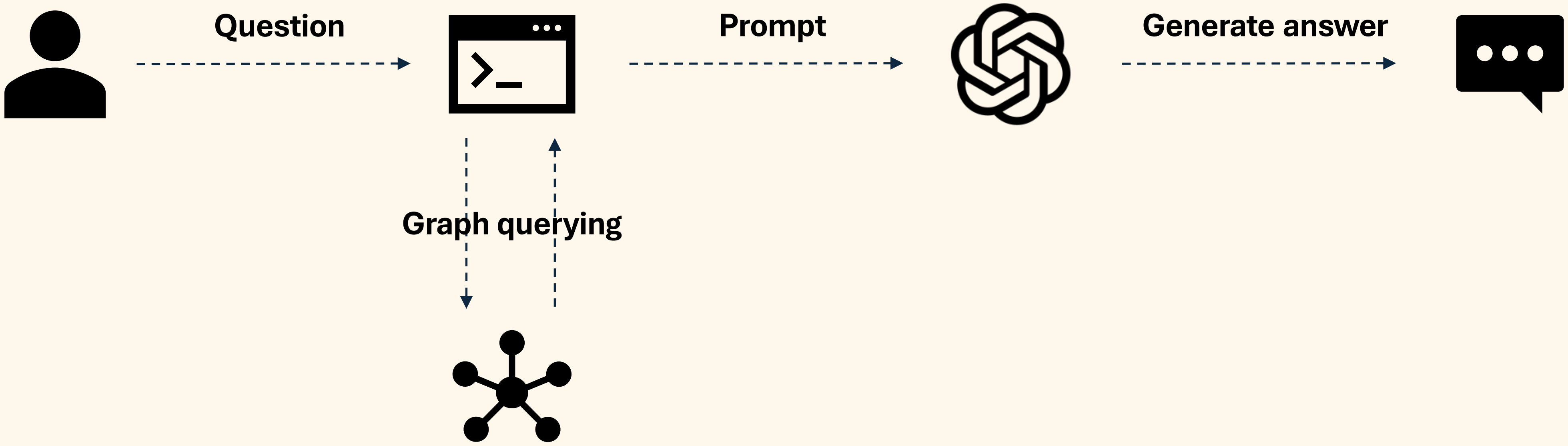
Prompt

Generate answer

Information retrieval
e.g. vector database

Module 3 Graphs meet LLMs

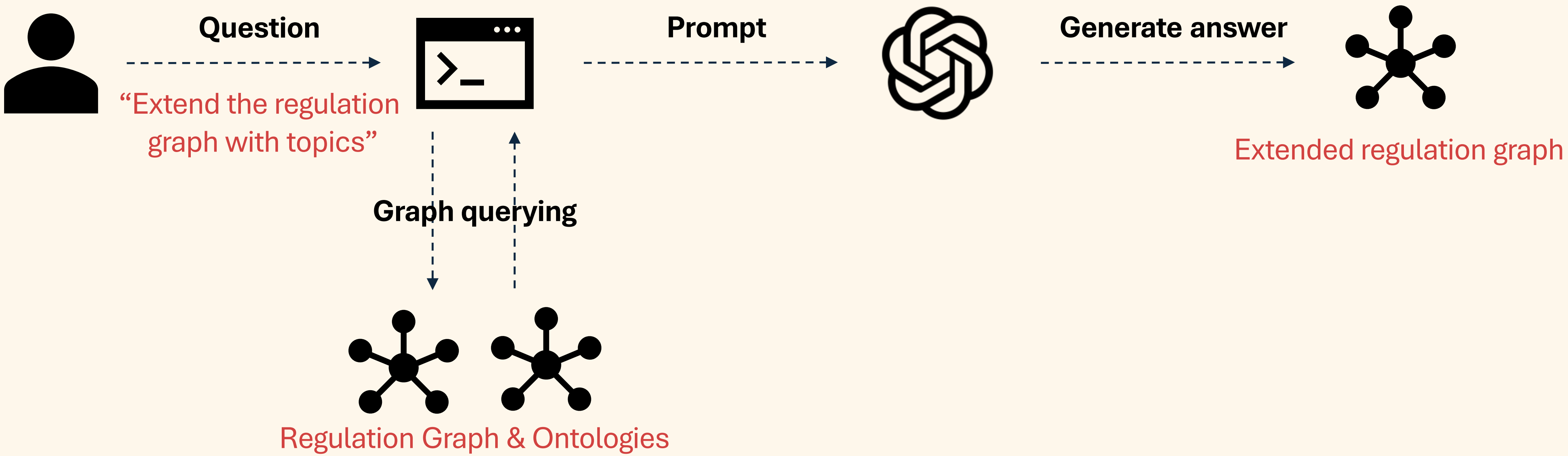
Basic **GraphRAG** pipeline



Module 3 Graphs meet LLMs

Pipelines that we'll test today:

```
fbr-nl:Clause_3.46
                rdf:type        fro:Clause ;
                fro:hasText "De volgens NEN 6075 bepaalde weerstand
                tegen rookdoorgang van een subbrandcompartiment naar
                een besloten ruimte in het brandcompartiment is ten
                minste 20 minuten."@nl .
                fro:isAbout     fbo:FireCompartment
```



Question

"Extend the regulation graph with topics"

Prompt

Generate answer

Extended regulation graph

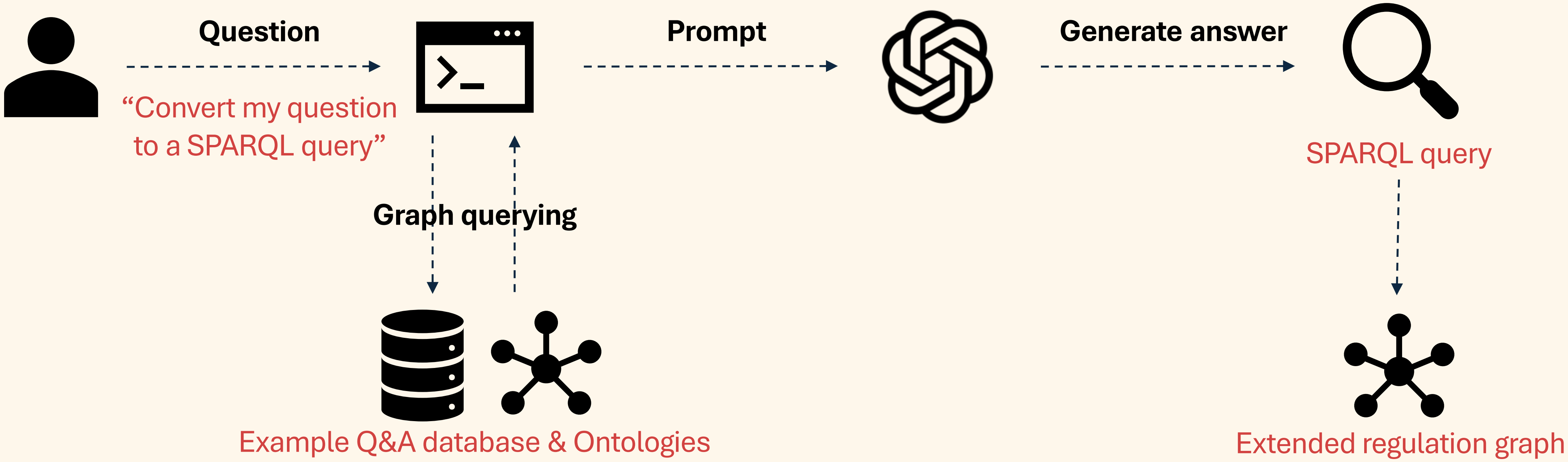
Graph querying

Regulation Graph & Ontologies

Module 3 Graphs meet LLMs

Pipelines that we’ll test today:

```
fbr-nl:Clause_3.46
                rdf:type        fro:Clause ;
                fro:hasText "De volgens NEN 6075 bepaalde weerstand
                tegen rookdoorgang van een subbrandcompartiment naar
                een besloten ruimte in het brandcompartiment is ten
                minste 20 minuten."@nl .
                fro:isAbout     fbo:FireCompartment
```



Question

“Convert my question to a SPARQL query”

Prompt

Generate answer

SPARQL query

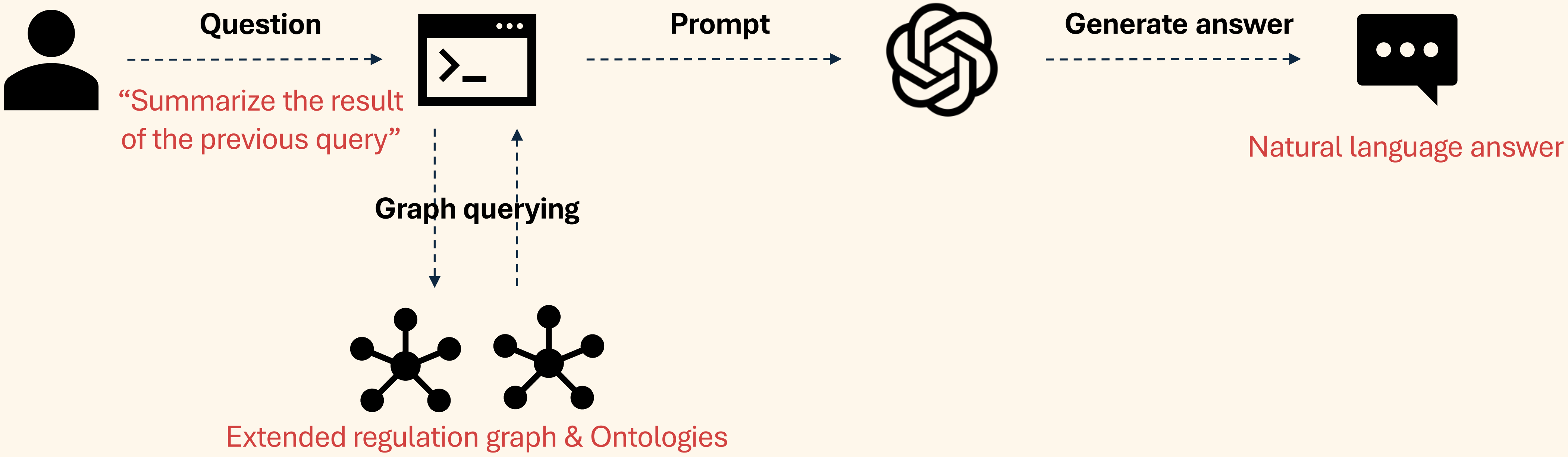
Graph querying

Example Q&A database & Ontologies

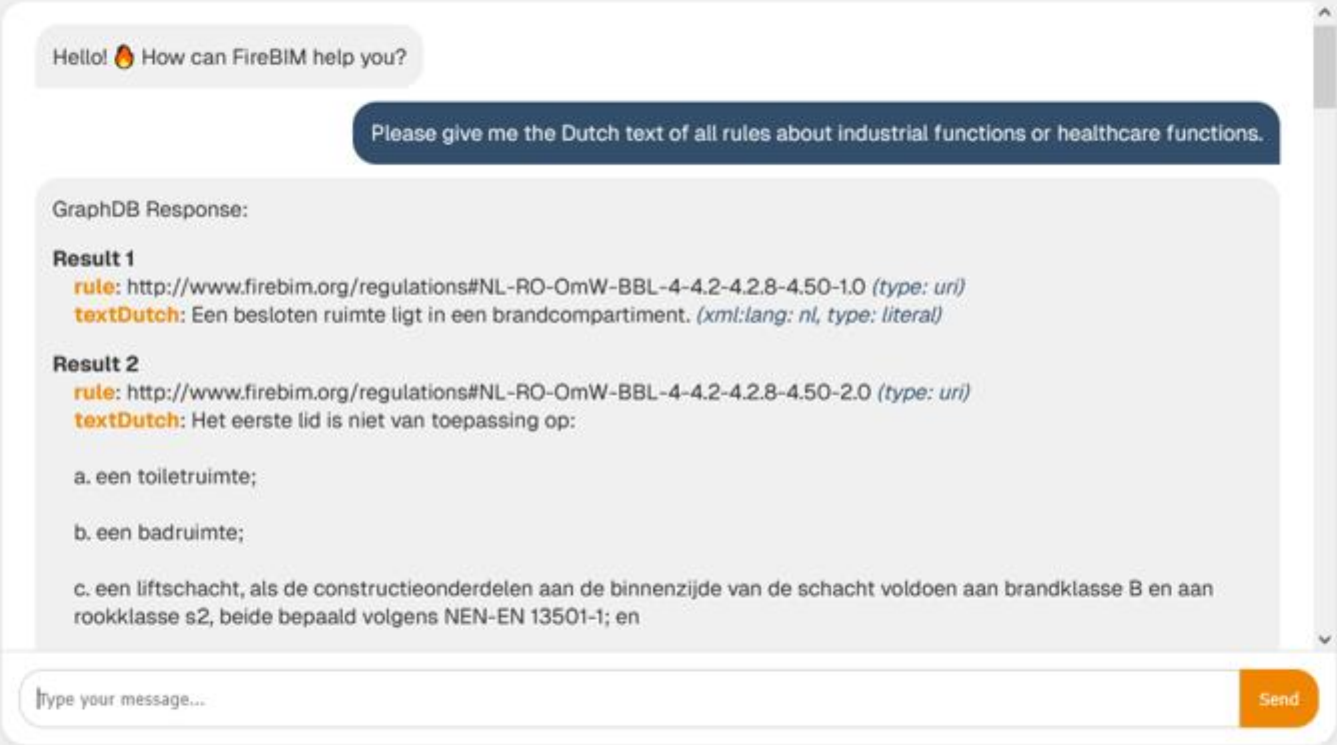
Extended regulation graph

Module 3 Graphs meet LLMs

Pipelines that we'll test today:


Question
"Summarize the result of the previous query"
Prompt
Generate answer
Natural language answer
Graph querying
Extended regulation graph & Ontologies

Chatbot example



Hello! 🔥 How can FireBIM help you?

Please give me the Dutch text of all rules about industrial functions or healthcare functions.

GraphDB Response:

Result 1
rule: http://www.firebim.org/regulations#NL-RO-OmW-BBL-4-4.2-4.2.8-4.50-1.0 *(type: uri)*
textDutch: Een besloten ruimte ligt in een brandcompartiment. *(xml:lang: nl, type: literal)*

Result 2
rule: http://www.firebim.org/regulations#NL-RO-OmW-BBL-4-4.2-4.2.8-4.50-2.0 *(type: uri)*
textDutch: Het eerste lid is niet van toepassing op:

a. een toiletruimte;

b. een badruimte;

c. een liftschacht, als de constructieonderdelen aan de binnenzijde van de schacht voldoen aan brandklasse B en aan rookklasse s2, beide bepaald volgens NEN-EN 13501-1; en

Let’s start coding! 🚀

1. Make a Gemini API key: https://aistudio.google.com/app/api-keys
2. Open the Notebook: https://colab.research.google.com/drive/1_Z2fGH9IzpnvosbnmclMQuU0T9b3oy0q?usp=sharing
3. Star/Fork the GitHub repository: https://github.com/AlexDonkers/ISBECodingCafe/
4. Ideas or comments? Please add an Issue or send an email

Thanks for joining!

Other open software and data:

https://github.com/AlexDonkers

Research:

https://research.tue.nl/nl/persons/alex-ja-donkers/

Big thanks to Özgün / TU/e Built Environment Coding Café, Eureka ITEA4 FireBIM and RVO