Knowledge Graph Lifecycle: Building and Maintaining Knowledge Graphs

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Outline

1. Introduction
2. Knowledge Graph Lifecycle
3. Lessons learned
4. Conclusion and Future Work
1. Introduction

- Knowledge graph lifecycle comes with two major challenges
  - map and integrate heterogeneous sources
  - maintain them to make a high-quality resource for an application at hand

- An experience report of our attempt to implement the lifecycle in various application scenarios

- Discussing lessons learned for
  - general implementation of the lifecycle
  - knowledge creation from heterogeneous sources (technical, conceptual and social challenges)
  - knowledge curation with different perspectives and scalability issues
2. Knowledge Graph Lifecycle

- Knowledge Creation
- Knowledge Hosting
- Knowledge Assessment
- Knowledge Cleaning
- Knowledge Enrichment
- Knowledge Curation
- Knowledge Deployment
2. Knowledge Graph Lifecycle

Tasks

Knowledge Graph Maintenance

Knowledge Creation
- Edit
- Semi-automatic
- Mapping
- Automatic

Knowledge Hosting
- Knowledge Assessment
  - Evaluation
  - Correctness
  - Completeness

Knowledge Curation
- Knowledge Cleaning
  - Error Detection
  - Error Correction

Knowledge Deployment
- Knowledge Enrichment
  - Knowledge Source detection
  - Knowledge Source integration
  - Duplicate detection
  - Property-Value-Statements correction
2. Knowledge Graph Lifecycle

Knowledge Graph Maintenance
- Knowledge Hosting
  - GraphDB
- Knowledge Curation
  - Quality Assessment Tool (QAT)
- Knowledge Cleaning
  - Error Detection
    - VeriGraph
  - Error Correction
- Knowledge Enrichment
  - Duplicate detection
  - Property-Value-Statements correction

Knowledge Creation
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- Automatic

Knowledge Assesment
- Knowledge Source detection
- Knowledge Source integration
- Duplicate detection

Tasks and their tools

RocketRML: An efficient RML Mapper implemented with NodeJS
https://github.com/semantifyit/RocketRML

Semantify.it

GraphDB

Conversational Agents

Knowledge Activators

Evaluation
- Correctness
- Completeness

Duplicate Detection as a Service (DDaS)
2. Knowledge Graph Lifecycle

- Knowledge Graph Maintenance
  - Knowledge Hosting
    - Knowledge Creation
      - Edit
      - Semi-automatic
      - Mapping
      - RocketRML
    - Knowledge Hosting
    - Knowledge Curation
      - Quality Assessment Tool
      - VeriGraph: Efficient error detection tool for instances in a Knowledge Graph based on integrity constraints
        https://github.com/semantifyit/VeriGraph
        https://semantify.it/verigraph
    - Knowledge Cleaning
      - Knowledge Source detection
      - Knowledge Source integration
    - Knowledge Enrichment
      - Duplicate detection
      - Property-Value-Statements correction
      - Duplicate Detection as a Service (DDaS)

- Knowledge Deployment

Tasks and their tools
2. Knowledge Graph Lifecycle

Knowledge Graph Maintenance

Knowledge Hosting

Knowledge Curation

Knowledge Deployment

Knowledge Creation

Knowledge Hosting

Knowledge Curation

Knowledge Enrichment

Knowledge Source detection

Knowledge Source integration

Duplicate Detection as a Service:
A duplication detection tool that can learn configurations for different scenarios and can be optimized for different criteria (e.g., precision, recall, F1)

Tasks and their tools

Semantify.it

GraphDB

Quality Assessment Tool (QAT)

VeriGraph

Duplication Detection as a Service (DDaS)

Conversational Agents

Knowledge Activators

Edit

Semi-automatic

Mapping

RocketRML

Automatic

Evaluation

Correctness

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Error Detection

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2. Knowledge Graph Lifecycle

Knowledge Graph Lifecycle:
- Knowledge Creation
  - Edit
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Tasks and their tools

Conversational Agents: Knowledge Graphs power conversational agents as a knowledge source and for training various machine learning models (e.g. NLU)
e.g. https://onlim.com
2. Knowledge Graph Lifecycle

Knowledge Generation

- Domain knowledge shared with domain-specific patterns of schema.org (and its extensions)
- YARRML syntax was an important decision factor for RML

Typically in JSON or XML format

highly configurable ETL tool to orchestrate the pipeline

PROV-O and schema.org used
2. Knowledge Graph Lifecycle

Knowledge Cleaning

- Error detection with integrity constraints defined based on domain-specific patterns (implemented with SHACL)

- VeriGraph developed
  - supports a subset of SHACL

- Some shortcomings encountered in the existing SHACL verifiers
  - tied to a triple store (e.g. Stardog)
  - does not work directly on SPARQL endpoints (e.g. reference implementation from TopBraid)
  - do not finish verification when the knowledge graph size go over magnitude of millions (e.g. RDFUnit)
    - the reason is most probably the network overhead of running SPARQL queries and creating verification reports

- Verification per instance: The instance relevant to a pattern is retrieved with a single SPARQL query (similar to using DESCRIBE queries). Less overhead over the network.
2. Knowledge Graph Lifecycle

Knowledge Enrichment

Duplicate Detection as a Service (DDaaS) is a service-oriented framework that allows linking duplicate instances within a Knowledge Graph or among Knowledge Graphs.

Inspired by DUKE, LIMES and SILK

DDaaS allows configuration learning for also indexing and pre-filtering phases and allows optimization for Precision, Recall or F-Score.

Most tools allow configuration learning for only duplication detection phase and optimizes F-score.
2. Knowledge Graph Lifecycle

Knowledge Deployment

- Open Touristic Knowledge Graphs
  - **Tyrolean Tourism Knowledge Graph**: Integrates heterogenous data from 10+ Destination Management Organizations (DMO) - 12B+ triples. University prototype and showcase.
  - **German Tourism Knowledge Graph**: Integrates heterogenous data from the Regional Marketing Organizations (LMO*) in Germany. Real-world application

- Dialog systems
  - Conversational agents that help users to achieve their goals with the help of Knowledge Graphs:
    - Knowledge Graphs as a source of domain knowledge (about static, dynamic and active data)
    - Knowledge Graphs for training Natural Language Understanding models

* Landesmarketing Organization
2. Knowledge Graph Lifecycle

We build the **Tyrol Knowledge Graph (TKG)** as our first showcase

- It is a published in **GraphDB** providing a **SPARQL** endpoint for the provisioning of touristic data of Tyrol, Austria.

- The TKG currently contains data about touristic infrastructure like accommodation businesses, restaurants, points of interests, events, recipes, et.

- Currently the TKG contains over 12B+ statements, 55% are explicit and 45% are inferred.

- [https://tirol.kg/](https://tirol.kg/)
2. Knowledge Graph Lifecycle

Knowledge Deployment

- The **German Tourism Knowledge Graph** will integrate semantically annotated tourism-related data from 16 LMOs/Magic Cities.

- Contracted by the Deutsche Zentrale für Tourismus (DZT), planned to be finished in 2022.
- An ecosystem for Knowledge Creation, Hosting and Deployment is being built.

- Compliant with the domain-specific patterns developed by **The Open Data Tourism Alliance (ODTA)**.
  - [https://ds.sti2.org](https://ds.sti2.org)

- Reference real-world implementation of the full lifecycle

- Read more at:
2. Knowledge Graph Lifecycle

Knowledge Deployment

Onlim Conversational Agents

We understand the question (data, context, semantics), query the knowledge graph and provide the right answer in natural language.

I'm looking for a restaurant with an electric charging station for my electric car in Wattens.

We recommend Gasthaus Schwan.

Gasthaus Schwan, Wattens
Restaurant  Currently open

Navigation  Charging station

Learning intents and data semantics out of the knowledge graph.

Query generation

Natural language generation

How can I help you? What are you interested in?

I'm looking for a hotel in Linz

Show intent  Show NULL result

Book an accommodation right away, or just have a look at them all?

Book now

Show intent  Show NULL result

What is your date of arrival (YYYY-MM-DD)?

2021-09-03

Show intent  Show NULL result

What is your date of departure (YYYY-MM-DD)?

2021-09-04

Tell me!
3. Lessons Learned

General Lessons

● **Orchestration of different tasks in the lifecycle**
  ○ Many of the individual tasks have been addressed in academia and industry, however a tool to orchestrate the lifecycle lacks
  ○ Need for open APIs and increased interoperability between tools supporting different tasks in the lifecycle

● **Community effort needed to maintain existing research products**
  ○ There is a great amount of important work in the academia addressing various tasks in the lifecycle, however many of them are not maintained (documentation/code outdated)
  ○ Is an effort similar to Apache Software Foundation a solution?
3. Lessons Learned

Knowledge Creation

- **Real data is not perfect, knowledge creation is not trivial**
  - In TKG use case we realized that it is very common to receive data without any fields for join operations
  - We currently work around this by using JSONPath+ and introducing a new construct called PATH~ to join based on the exact path of nested elements

- **Conceptual and social challenges stand**
  - Declarative mappings solve a technical problem
  - The domain experts must define the domain by identifying relevant types, properties, and constraints and communicate them to the developers and mapping creators. This is particularly challenging when these actors are distributed across different organizations, as it is in the German Tourism Knowledge Graph.
  - Simple human- and machine-understandable patterns of schema.org and its extensions published by domain experts improve the knowledge creation process significantly.
3. Lessons Learned

Knowledge Curation

- **Different perspectives on knowledge integrity**
  - One experience we had with Tyrolean and German Tourism Knowledge Graph use cases is that the different instances of the same type may have different expected shapes.
    - For instance, a generic Organization shape may require schema:vatID property however for a schema:Organization instance that is the value of organizer property of an event only the name property may be interesting. A SHACL shape that targets the schema:Organization type would verify both Organization instances, which is not the intended behavior.
    - Domain-specific patterns as types with local properties and ranges and directly connect to instances

- **Distinguishing between different kind of constraints may help optimizing cleaning process**
  - Verifying mappings vs verifying the knowledge graph
  - For the cases where mappings can be controlled
  - Important for improving verification efficiency for time-sensitive applications like conversational agents
4. Conclusion and Future Work

- Introduced the knowledge graph lifecycle and solutions produced for some of the tasks

- Discussed lessons-learned

- Time-sensitive applications like conversational agents require high-quality data really fast.
  - this may be challenging as the knowledge graph grows

- Part of our current and future work is to only curate a relevant part of a knowledge graph for an application at a given time. This allows
  - Supporting different point of views in “micro TBoxes”
  - Reducing the time needed for curation