Rapid Engineering of Question Answering Systems using the lightweight Qanary Approach

Tutorial at JIST 2017

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at DATEV eG

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http://wdaqua.eu, https://github.com/WDAqua/

Tutorial Plan

Introduction and Motivation
- Question Answering
- Question Answering Systems

Qanary Methodology and Technical Framework
- Idea
- Knowledge Representation using the qa Vocabulary
- Qanary Methodology

Technical Part
- Interactive Session: Solution Definition
- Coding Session: Implement your first QA system from existing components
- Validate the quality of your QA system
- Improve and revalidate your QA system
- Solve new QA tasks

Final Remarks

Introduction and Motivation

Something about me

Dr. Andreas Both

– 2005 Studies of Computer Science, University Halle (Germany)

– 2010 PhD in Software Engineering and Programming Languages, University Halle (Germany)

– 2012 Project Lead of "Semantic Web Project" (R & D), Unister GmbH (Germany)

– 2015 Head of Research and Development Department, Unister GmbH (Germany)

2016 Research and Development Lead Mercateo AG (Germany)

11/2016 – Head of Architecture, Web Technology and IT Research, DATEV eG (Germany)

DATEV eG: https://www.datev.com/

- software company and IT service provider
- turnover: $>$ 900 million euros
- age: $>$ 50 years old
- core market: Germany
- fields: accounting, business consulting, taxation, enterprise resource planning (ERP) as well as organization and planning
- members: $>$ 40.000
- customers: $>$ 2.6 million companies

Today's Goals

You will ...

- receive a compact overview about Question Answering (QA) and its challenges
- understand the $Qanary$ methodology, the RDF vocabulary qa and the component-oriented $Qanary$ framework
- learn to iteratively build, validate and improve your own QA system using the $Qanary$ framework

Thereafter, you will ...

- be enabled to implement you own QA system
- take advantage of the Qanary ecosystem for rapid research results
- contribute to the research community to improve the state-of-the-art

Schedule

30 min Introduction

30 min Question Answering (QA) using $Qanary$

20 min RDF-based knowledge design of a QA problem using the qa vocabulary

15 min coffee break

30 min exercise: model QA ontology using the qa vocabulary, write SPARQL queries for answering exemplary questions

40 min exercise: implement your own QA system using $Qanary$

10 min conclusions and outlook

Question Answering

Introduction on Question Answering

Overview

- aim: answer users questions using given data
- importance: enables user to actually work with Big Data
- challenges: ambiguity of language, large data sets,
- technologies: information retrieval (IR), natural language processing (NLP), Linked Data & Semantic Web, artificial intelligence (AI), ...

Attributes of QA

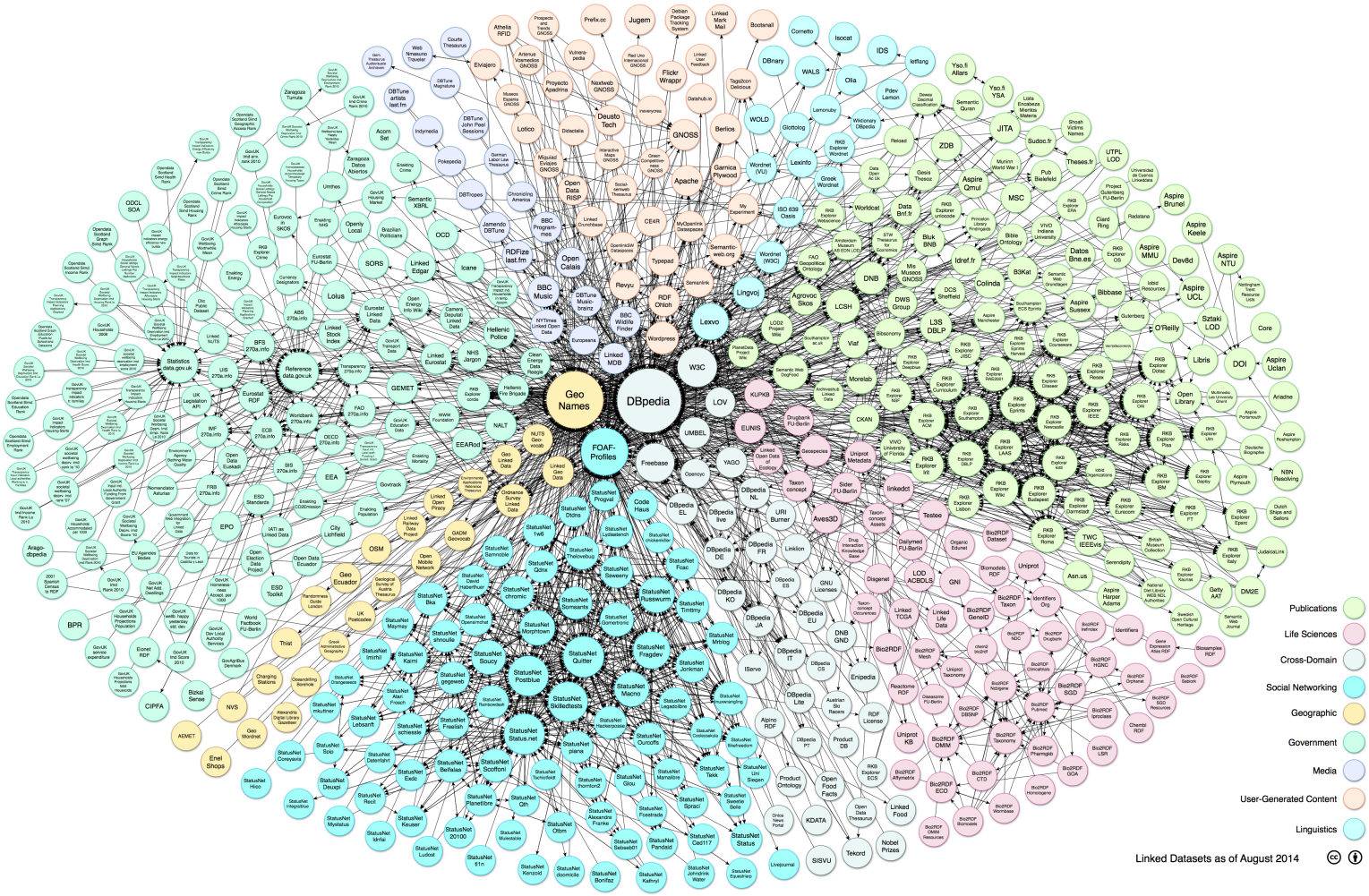
- fact-based
- text-based
- statistical
- multilingual
- community-based
- closed/open domain
- hybrid
- visual
- ...

Introduction on Question Answering

Our Focus

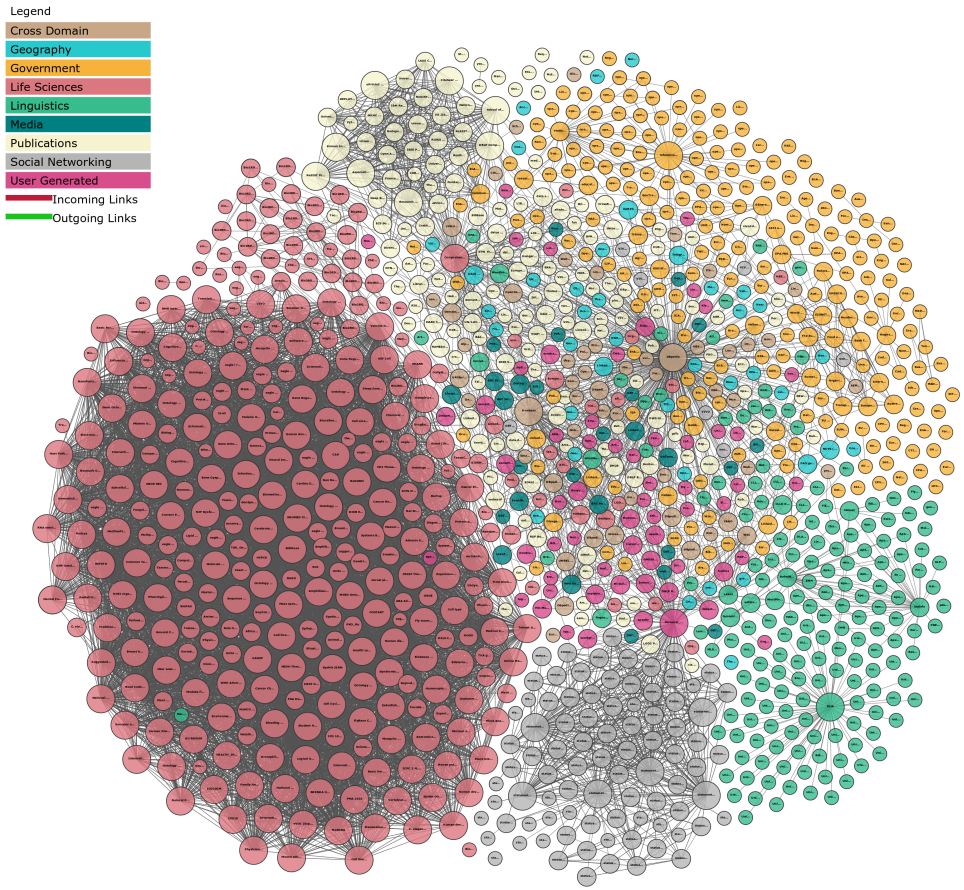
- natural language input
  - general: (multilingual) natural language, factoid questions
  - today: English questions
  - examples:
    - "What is the real name of Batman?"
    - "Is Bruce Wayne the real name of Batman?"
    - "How many partners had Batman?"
  - possible sources to answer the questions: en.wikipedia.org/wiki/Batman, dbpedia.org/resource/Batman, wikidata.org/wiki/Q2695156
- structured data sets as knowledge base
  - DBpedia, Wikidata, Freebase, ...
  - today: DBpedia

Excursus: Linked Open Data Cloud



http://lod-cloud.net/

Excursus: Linked Open Data Cloud



Linking Open Data cloud diagram 2017, by Andrejs Abele, John P. McCrae, Paul Buitelaar, Anja Jentzsch and Richard Cyganiak. `http://lod-cloud.net/`

Question Answering Benchmarks

Challenge to Measure the Quality of QA systems

- high variety of questions
- training requires data
- comparability requires gold standards

QA Benchmarks

- Question Answering over Linked Data (QALD)
  - hundreds of questions
  - tasks: Multilingual QA over DBpedia, Hybrid Question Answering, English question answering over Wikidata
  - website: `http://www.sc.cit-ec.uni-bielefeld.de/qald`
  - e.g., QALD-8 challenge at ISWC 2017
- Largescale Complex Question Answering Dataset (LC-QuAD)
  - thousands of English questions
  - `https://iswc2017.semanticweb.org/paper-152/`
  - website: `http://lc-quad.sda.tech/`

Question Answering Systems

Introduction on Question Answering Systems

- BASEBALL[1]
  - very early QA system (1963)
  - using baseball database
  - answers questions w.r.t. dates, locations, ...
- START Natural Language Question Answering System[2]
  - open-domain QA system
  - uses particular knowledge bases
  - demo: `http://start.csail.mit.edu/`

Introduction on Question Answering Systems

- WATSON[3]
  - well known from the Jeopardy show
  - industrial applicability in several domains
  - website: `https://www.ibm.com/watson/`
- Siri[4]
  - answering of (spoken) user questions targeting predefined domains
  - knowledge base representing the iOS functionality
  - common knowledge
- many more: LUNAR (1977), PHLIQA 1 (1978), AquaLog (2004), YodaQA (demo, 2015), ...

State-of-the-Art of QA Systems

Qanary-based QA system: WDAqua QA

- on-top of *Qanary* framework
- targets: DBpedia, Wikidata, MusicBrainz (open music encyclopedia) and DBLP (computer science bibliography)
- custom implementation of answer computation
- *Qanary*-compatible front-end "Trill"
- demo: www.wdaqua.eu/qa

Existing QA systems

Observations

- state of the art not as advanced as expected
- see also QALD challenge

Reasons: How are question answering systems created?

- in general: hard and complex task
- cumbersome and inefficient
  - lack of *methodology* for creating question answering systems

Processing Steps within QA systems

- Query Analysis and Classification
  - Named Entity Recognition
  - Entity Linking, Named Entity Disambiguation
  - Relation Detection
  - Query Type Detection
- Query (Candidate) Building (e.g., SPARQL, SQL, Query DSL, . . .)
- Query (Candidate) Ranking (e.g., learning to rank using a gold standard)
- Answer Generation (e.g., Natural Language Generation, data visualization, . . .)
- Answer Validation (Feedback)

→ **many similar tasks and distinguished technology**

Note: Sometimes steps are not needed or need to be executed several times (loops) to take advantage of the available knowledge. A good QA framework should not request limitations here (*Qanary* has no such limitations).

Motivation for using a QA framework

Observations and Requirements

Observations

- limited compatibility
- use predefined QA process
- limited semantics

Derived demands

+ interoperable infrastructure
+ exchangeable components
+ flexible granularity
+ isolation of components

Goals

1. easy-to-build QA systems on-top of reusable components
2. establish an ecosystem of components for QA systems

→ efficient research steps → enabling of synergies between PhD topics

→ **best-of-breed QA system & components for use cases and research topics**

Qanary Methodology and Technical Framework

Idea: Knowledge-driven QA system representation

Requirements of knowledge perspective

1. abstract knowledge representation: qa vocabulary
   - represent all the available knowledge about a question
     - + representation of knowledge about question separated from process
     - + includes trust & provenance
     - + self-describing, reusable and extensible
     - + enables efficient collaboration on a data-level
     - + agnostic to question format (text, structured, audio, . . .)
     - + agnostic to question answering processing steps and implementation
2. align the input/output of the each component in a QA process
   - required input mapped from KB
   - computed output mapped into KB
   - mapping on a logical and sound level

→ *Qanary* methodology for creating question answering systems

Knowledge Representation using the qa Vocabulary

Abstract Knowledge Representation

Idea

Represent all the knowledge about a question using a RDF vocabulary

requirements for knowledge representation

- self-describing, sound knowledge representation
- represent provenance for (all) information
- represent trust for (all) information

derived technology stack

- Resource Description Framework (RDF)
- Web Annotation Data Model (WADM)
- question answering vocabulary (qa)

Resource Description Framework (RDF)

Introduction to RDF (slides by Manolis Koubarakis)
`http://cgi.di.uoa.gr/~pms509/past_lectures/introduction-to-rdf.pdf`

Web Annotation Data Model (WADM)

Web Annotation Data Model (WADM)

(W3C Working Draft 15 October 2015, http://www.w3.org/TR/annotation-model)

- oa:Annotation
- oa:hasTarget
- oa:hasBody
- oa:annotatedAt
- oa:annotatedBy

```
<myIRI> a oa:Annotation;
   oa:hasTarget <questionIRI> ;
   oa:hasBody <TextSelector> ;
   oa:annotatedBy <DBpediaSpotlight> ;
   oa:annotatedAt "..."^^xsd:date ;
```

qa Vocabulary

introducing new QA-related concepts on-top of WADM:

```
qa:Question
    rdfs:subClassOf oa:Annotation.
qa:Answer, ...
qa:Dataset, ...
qa:AnnotationQuestion, ...
...
```

- K. Singh, A. Both, D. Diefenbach, and S. Shekarpour. "Towards a message-driven vocabulary for promoting the interoperability of question answering systems." In Proc. of the 10th IEEE Int. Conf. on Semantic Computing (ICSC), 2016
- website: `https://github.com/WDAqua/QAOntology`

From knowledge representation to methodology

Conclusion: Advantages of using an ontology

- agnostic to question format (text, structured, audio, . . .)
- agnostic to question answering processing steps
- agnostic to implementation
  - programming language
  - component granularity

From knowledge representation to methodology

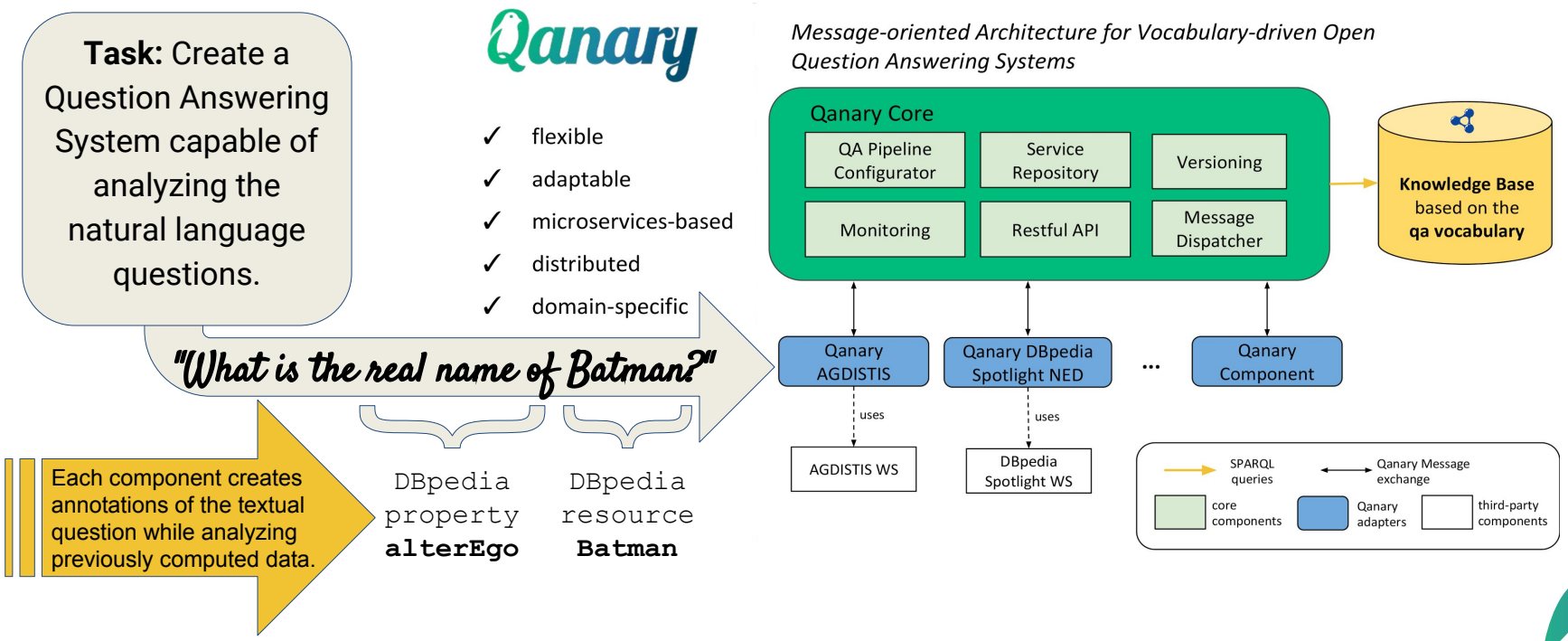
Methodology

1. abstract knowledge representation
   - advantage: independent representation
2. align the input/output of the each component
   - on a logical and sound level

Qanary Methodology

Overview

A trivial Question Answering system



It's about the components, stupid.

- an *agile* QA framework can only provide common features
  - central data access, logging, ...
- any particular problem solving/algorithm needs to be separated from the pipeline

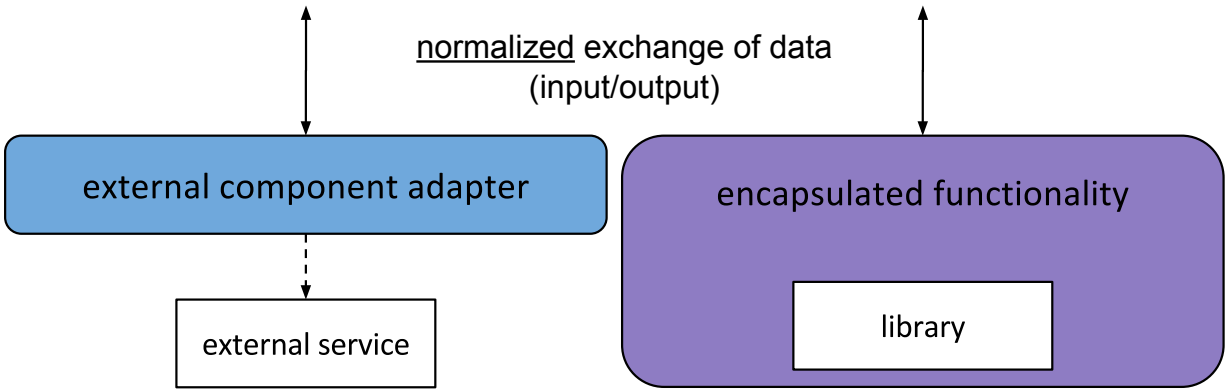
→ create exchangeable, isolated components only communicating via data

→ component data needs to be mapped/aligned to the data of the QA process

Component data alignment

Goal: Establish common ground for the research community

Two options:



alignment of input/output of each component with qa

- input represented using qa (RDF)
  → input required for the component C
- output from the component C
  → output represented using qa (RDF)

Component data alignment

alignment of input/output of each component with qa

if component provides output using a presentation as

. . . semantic data (RDF)
- logical representation of alignment
  - ontology alignment (OWL, DOL)
  - SPARQL query

. . . non-semantic data (API, JSON, XML, CSV, . . .)
- SPARQL query

Note: many options for alignment

- NER/NED
  - DBpedia Spotlight (NIF)
    P. N. Mendes, M. Jakob, A. Garca-Silva, and Ch. Bizer: "DBpedia Spotlight:shedding light on the web of documents." In I-SEMANTICS, 2011
- relation detection
  - PATTY
    N. Nakashole, G. Weikum, and F. M. Suchanek. PATTY: "A taxonomy of relational patterns with semantic types." In EMNLP-CoNLL, 2012
- query construction
  - SINA
    S. Shekarpour, E. Marx, A.-C.N. Ngomo, and S. Auer. SINA: "Semantic interpretation of user queries for question answering on interlinked data." Web Semantics: Science, Services and Agents on the WWW, 2015

Component data alignment: NED

- create component's input:
  - fetch question URI (from Qanary triplestore)
- processing:
  - retrieve textual question representation from URI
  - compute named entities within the text
- store component's output:
  - for each named entity:
    - create a `oa:TextSelector` within the Qanary triplestore containing the positions of the particular Named Entity

→ benefit: easily replace the NED component

→ benefit: measure quality against exchangeable relation detection and query construction components

Component data alignment: Relation Detection

Relation Detection Example

- create component's input:
  - fetch question URI (from Qanary triplestore)
  - fetch Named Entities which are already available
- processing:
  - retrieve textual question representation from URI
  - compute relations within the text
- store component's output:
  - for each detected relation:
    - create a relation resource within the Qanary triplestore (using a `oa:TextSelector` to mark the positions)

→ benefit: any improvement on the NED component (i.e., replace) will improve the quality here

→ benefit: measure quality against exchangeable query construction components

Component data alignment: Query Construction

SPARQL Query Construction

- create component's input:
  - fetch Named Entities (which are already available)
  - fetch Relations (which are already available)
- processing:
  - compute SPARQL
- store component's output:
  - for each created SPARQL:
    - store a resource/SPARQL in the Qanary knowledge base

→ benefit: any improvement on the NED component (i.e., replace) will improve the quality here

→ benefit: any improvement on the Relation detection component (i.e., replace) will improve the quality here

Component data alignment: Relation Detection

Relation Detection Example

- create component's input:
  - fetch question URI (from Qanary triplestore)
  - fetch Named Entities which are already available
- processing:
  - retrieve textual question representation from URI
  - compute relations within the text
- store component's output:
  - for each detected relation:
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Component data alignment: NED

- create component's input:
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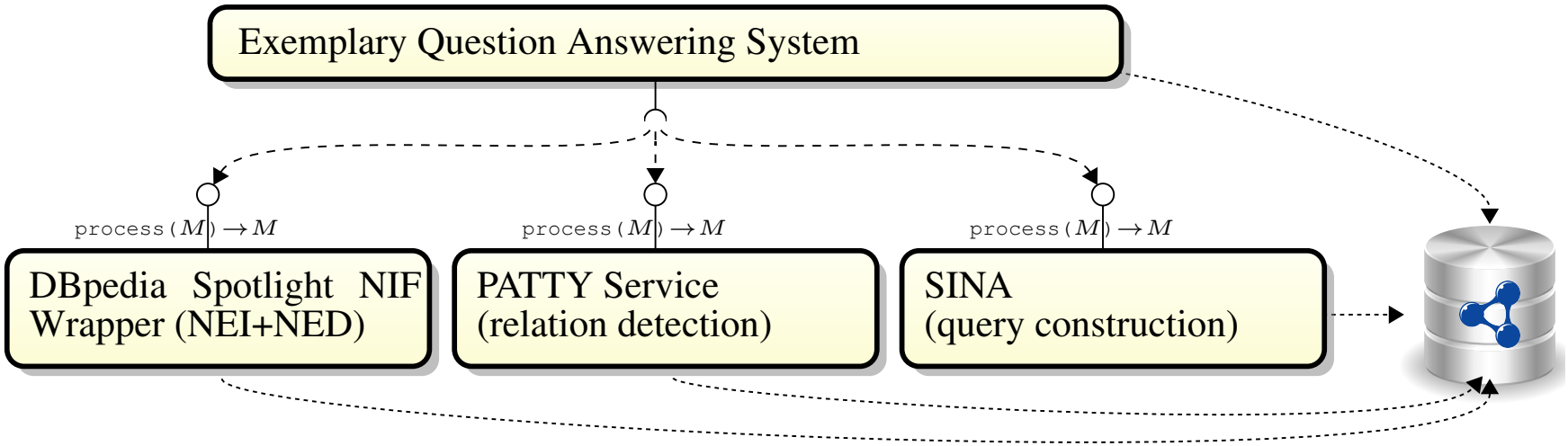
Case Study



Component

1. DBpedia Spotlight
2. PATTY
3. SINA query execution

Process within components

1. retrieve data from KB
2. process data
3. extend KB

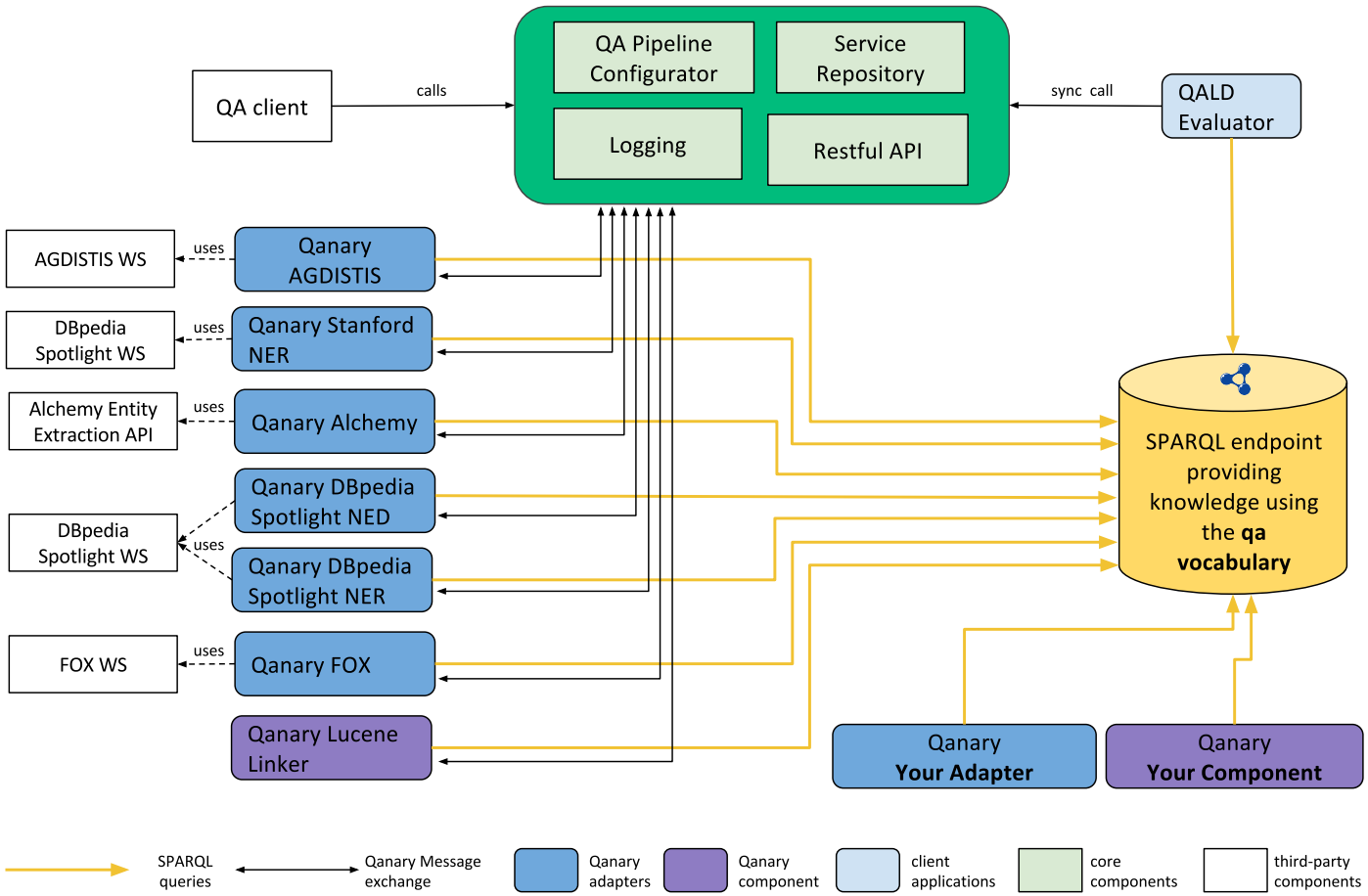
→ vocabulary-driven, component-oriented QA system possible

Available Architecture

- goal: easy-to-use framework for creating QA systems

Qanary

Message-oriented Architecture for vocabulary-driven open Question Answering systems



Outlook/Roadmap

- goal: enable infrastructure for optimizing/training of data interpretation
  - establish a methodology for representing goal standards within the qa vocabulary
  - provide a component for training on-top of ontology

  → best-of-breed QA system for your scope of application
- goal: reduce integration efforts (beyond RDF)
  - provide RESTful service interfaces for read/write access

  → even easier integration in external systems
- goal: automatic QA process creation
  - express/analyze data requirements for components

  → you define only your component, Qanary fulfills requirements
- goal: *provide benefits for your work*

Take Away: Qanary methodology

- Qanary: knowledge-driven methodology for QA systems
  - *and* reference implementation of methodology, too
- build on-top of the qa vocabulary
- agile approach for creating QA systems
  - interoperable infrastructure, exchangeable components, flexible granularity, isolation of components,
  - collects data in a sound way (provides support for AI components, particularly ensemble learning), does not fix the QA process to a template, allows concurrent executions, enables multi-path execution, freedom of candidate/option filtering (your/developers choice)
- *ecosystem of QA components* enabling best-of-breed approaches for your research topics

Join Qanary at Github!

github.com/**WDAqua/Qanary**

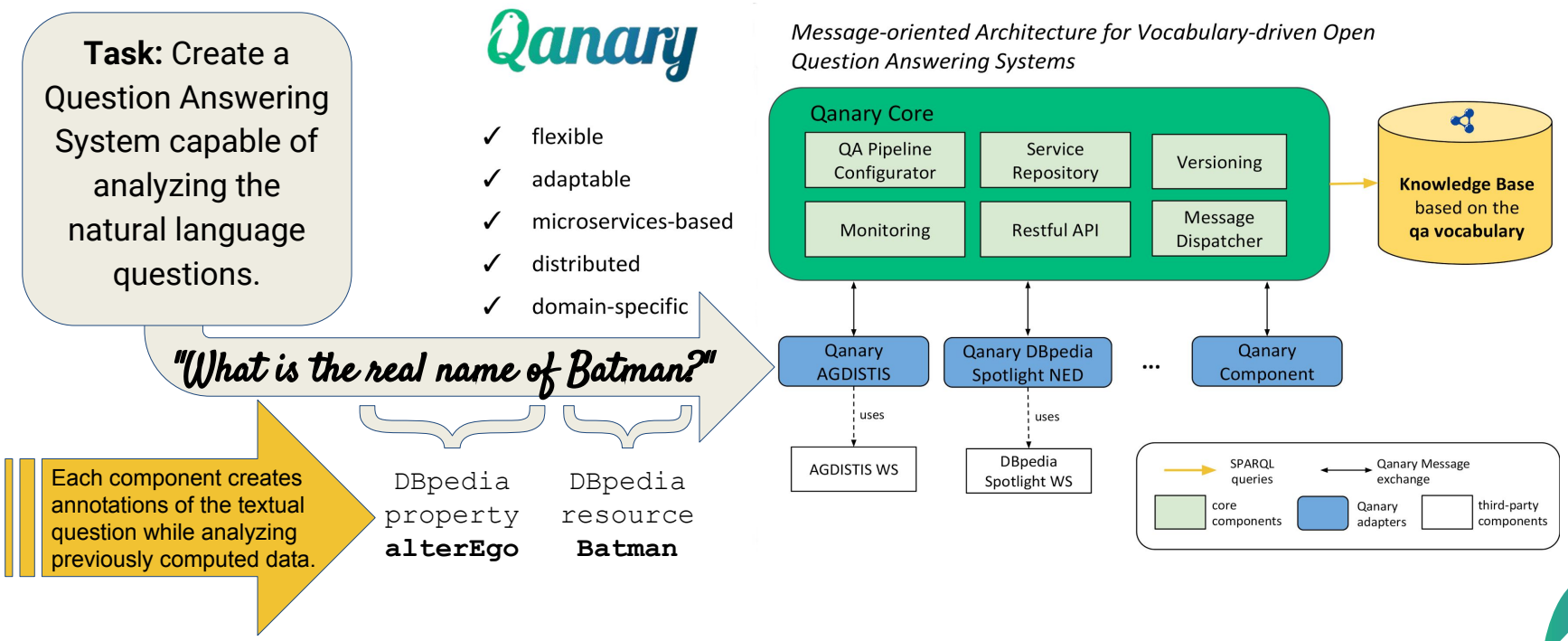
Coffee Break

Have break and prepare your notebook.
In the following practical session you will need:

- Internet connection
- text editor or any Ontology Designer
- Git client
- Java and Maven
- Stardog triplestore (free version)

Our Goal

Implementation of a trivial Question Answering system using *Qanary*



Let's define pairs/groups using the ranking ...

Interactive Session: Solution Definition

Preparation (15 min interactive session)

Given questions:

- "What is the real name of Batman?"
- "Is Bruce Wayne the real name of Batman?"
- "How many partners had Batman?"

Your Tasks

- model the required annotations for answering these questions
- write the SPARQL query to retrieve the answers for these queries

Note: Typically, the result of a QA process is not a SPARQL query. Due to time constraints, we exclude the mostly following Answer Generation (e.g., using Natural Language Generation or visualizations) from this exercise. See wolframalpha.com from inspiration.

Coding Session: Implement your first QA system from existing components

1. Step: Implement your first QA system

We follow the description on github.com/WDAqua/Qanary/wiki/Demo:-How-to-Create-a-Question-Answering-System-capable-of-Analyzing-the-Question-%22What-is-the-real-name-of-Batman%3F%22

- git checkout Qanary ecosystem's components
- run components
- run Qanary QA system template
- configure your pipeline
- run the pipeline
- test your QA system with some questions on DBpedia
- done

Validate the quality of your QA system

2. Step: Validate the quality of your QA system

- interactive validation using TRILL front-end from Qanary ecosystem
- use Qanary QALD validator to compute precision, recall and f-measure

Improve and revalidate your QA system

3. Step: Improve and revalidate your QA system

- solve questions not implemented before ...
  - pick from prepared list
  - define test cases
  - extend functionality
  - validate results in triplestore
- ...

4. Step: Solve new QA tasks

- extend the qa vocabulary
- choose existing QA components supporting your task
- implement new QA component for your new use case
- extend test cases and validate your work

Final Remarks

Summary

- compact overview about Question Answering (QA) and its challenges
- $Qanary$ methodology, the RDF vocabulary qa and the corresponding component-oriented $Qanary$ framework (reference implementation)
- advantage of the Qanary ecosystem for rapid research results
- learn to iteratively build, validate and improve your own QA system using the $Qanary$ framework
- you built a QA system capable of answering generic question in a specific domain (not only the exemplary questions)

→ I am looking forward to your contribution to the research community to improve the state-of-the-art

Take Away: Qanary methodology

- Qanary: knowledge-driven methodology for QA systems
- build on-top of the qa vocabulary (i.e., knowledge-driven approach)
- agile approach for creating QA systems
  - interoperable infrastructure, exchangeable components, flexible granularity, isolation of components, supports AI-approach
- today, was your first step towards participating in the $Qanary\ ecosystem\ of\ QA\ components$ enabling best-of-breed approaches for future QA systems

Join Qanary at GitHub!

github.com/**WDAqua/Qanary**

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