Querying APIs with SPARQL: language and worst case optimal algorithms

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Outline

Introduction

Preliminaries

SPARQL and JSON API calls

WCO Algorithm

Experiments

Conclusion

Introduction

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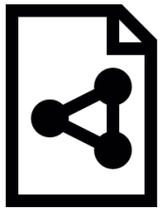

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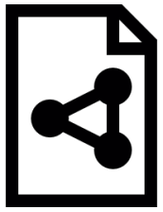

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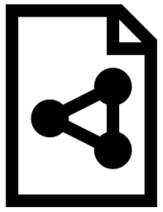

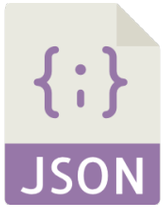

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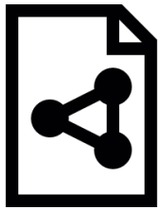

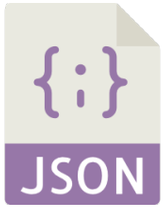

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How can we integrate such data?

How can we do that as efficient as possible?

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In this talk

A way to enable SPARQL to integrate data from JSON Web APIs extending the SERVICE operator

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Experimental results for the algorithm

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Preliminaries
SPARQL

We use the usual syntax and semantics of SPARQL, considering:

Tripple patterns
AND
OPTIONAL
UNION
FILTER
SERVICE

Preliminaries

SERVICE

Preliminaries

SERVICE

```
SELECT ?name ?weather
WHERE
{
  ?city :comuneOf :Chile .
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Preliminaries

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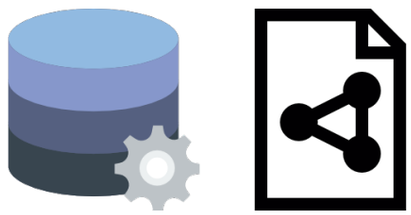

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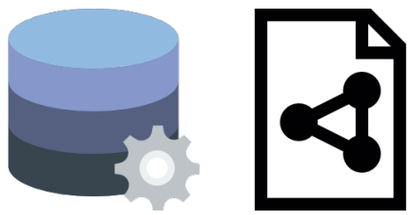

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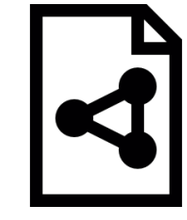

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Preliminaries

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Accessing multiple *Endpoints* in a single query

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Preliminaries

Web APIs

Interfaces that expose data through HTTP requests

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```
http://weather.org/s?lat=-33.45&lon=-70.6
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Interfaces that expose data through HTTP requests

```
http://weather.org/s?lat=-33.45&lon=-70.6
```

```
{
  “city”: “Santiago”,
  “status”: “Sunny”,
  “temperature”: {
    “min”: “14ºC”,
    “max”: “29ºC”
  }
}
```

Preliminaries

JSON Documents

We assume that APIs responses are JSON Documents

We retrieve data from JSONs with *navigation conditions*

Preliminaries

Navigation Conditions

For the following JSON ***J***, the navigation condition `J["temperature"]["min"]` returns `"14ºC"`

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SERVICE Extension

Example

Suppose we want to do some *hiking* in Scotland, but we want to go to mountains located in places that are sunny

SERVICE Extension

Example

```
SELECT ?x ?l WHERE {
   ?x wdt:instanceOf wd:mountain .
   ?x wdt:locatedIn wd:Scotland .
   ?x rdfs:label ?l .
   SERVICE <http://weather.api/request?q={?l}>{
      (["description"]) AS (?d)
   }
   FILTER (?d = "Sunny")
}
```

SERVICE Extension

Example

We first resolve the *bgp*:

```
?x wdt:instanceOf wd:mountain .
?x wdt:locatedIn wd:Scotland .
?x rdfs:label ?l
```

?x	?l
wd:Q104674	“Ben Nevis”
wd:Q13130255	“Mount Blair”

SERVICE Extension

Example

And then we extend each mapping for the value provided by the API

```
SERVICE <http://weather.api/request?q={?l}>{
   (["description"]) AS (?d)
}
```

?x	?l	?d
wd:Q104674	“Ben Nevis”	“Sunny”
wd:Q13130255	“Mount Blair”	“Rain”

SERVICE Extension

Example

Then we apply the filter

```
FILTER (?d = “Sunny")
```

?x	?l	?d
wd:Q104674	“Ben Nevis”	“Sunny”

SERVICE Extension

Syntax

P_1 SERVICE U { (N_1,…, N_m) AS (?x_1, …, ?x_m) }

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P_1 is a SPARQL Pattern

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```
["description"], ["temperature"]["min"]
```

SERVICE Extension

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P_1 SERVICE U { (N_1,…, N_m) AS (?x_1, …, ?x_m) }

?x_1,…, ?x_m are variables not appearing in P_1 where the JSON Values will be bound

SERVICE Extension

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?v_1	…	?v_n
…	…	…
	μ	
…	…	…

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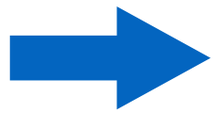

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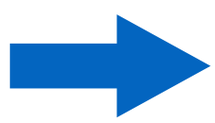

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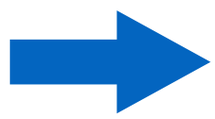

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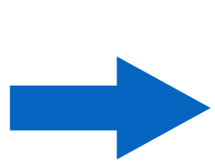

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Call_API(U, μ)

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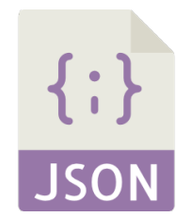

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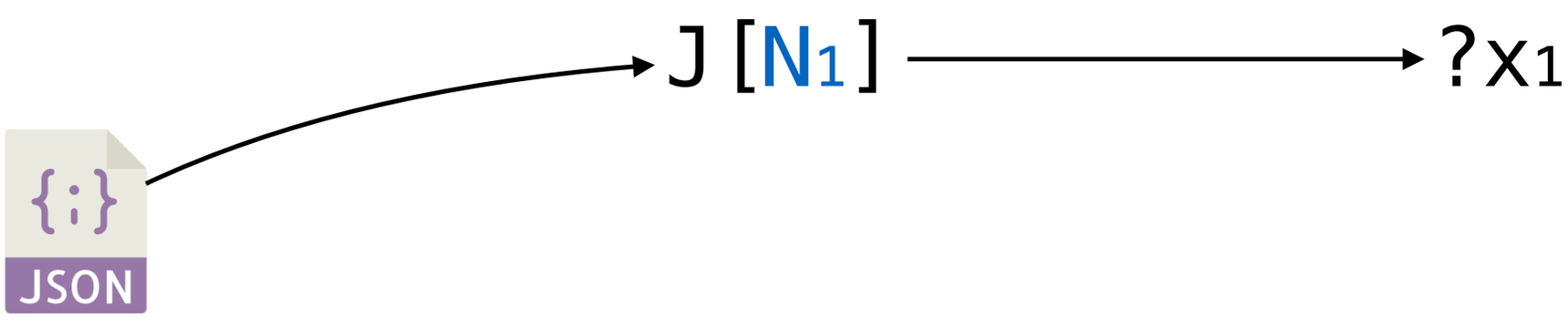

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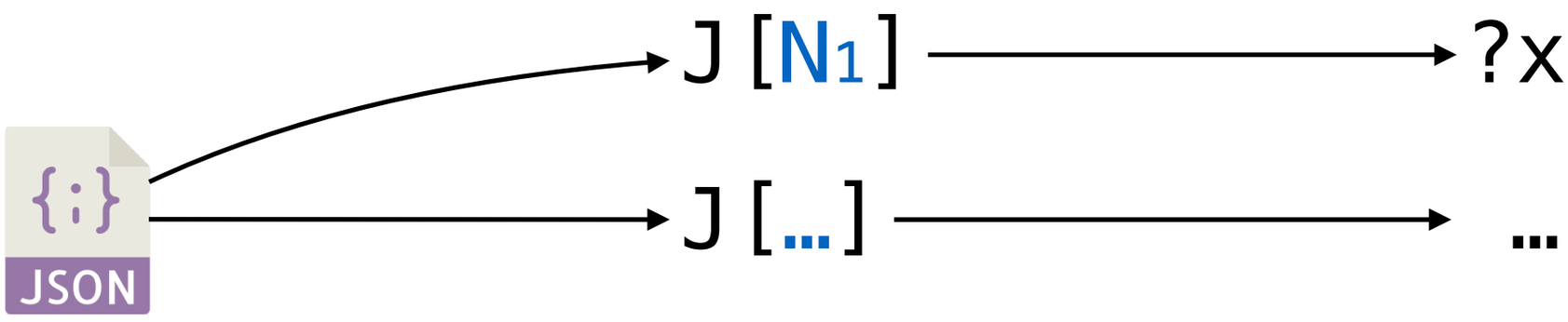

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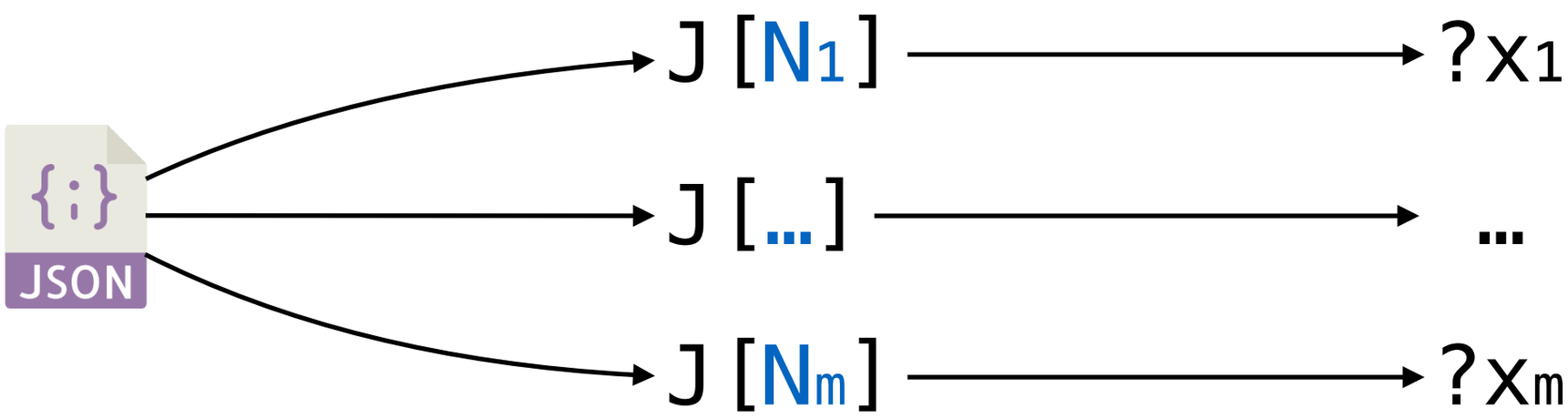

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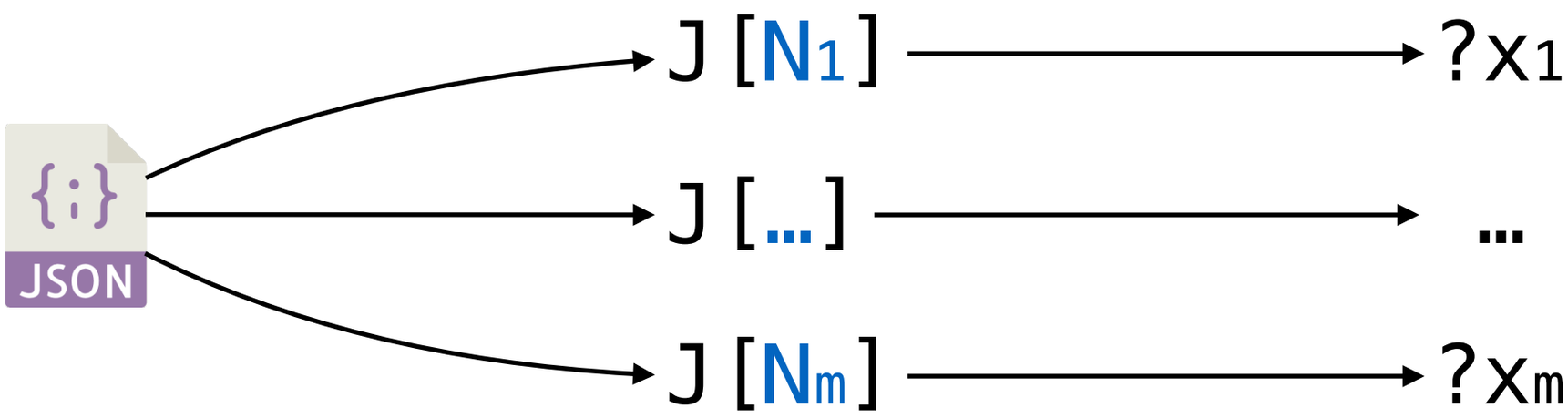

The mapping μ is extended with variables ?x_1, …, ?x_m

SERVICE Extension

Basic Implementation

P_1 SERVICE U { (N_1,…, N_m) AS (?x_1, …, ?x_m) }

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Basic Implementation

P_1 SERVICE U { (N_1,…, N_m) AS (?x_1, …, ?x_m) }

- Compute P_1 (recursively if it contains another SERVICE-to-API)
- Compute a set of Mappings **M**, where each mapping of P_1 is extended with the new variables
- Serialize each mapping of **M** with VALUES, and to allow them to be used by the next graph pattern

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Improving the algorithm

In a classical setting, we would like to minimize the calls to disk

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But what is the main bottleneck for SERVICE-to-API queries?

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But what is the main bottleneck for SERVICE-to-API queries?

We ran 4 queries with real use cases of SERVICE-to-API

Improving the algorithm

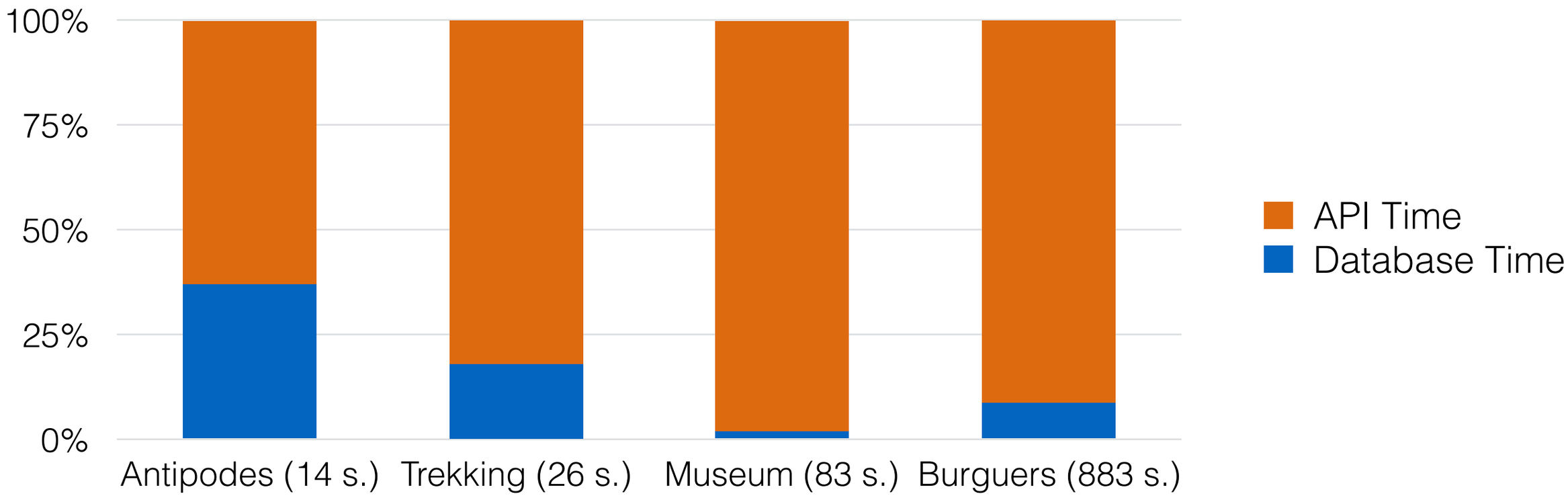

Figure 1: queries that used the APIs of OpenWeather, Yelp and Twitter

Worst Case Optimal Algorithm

In this setting, the main bottleneck is the number of calls done to the APIs

Worst Case Optimal Algorithm

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We developed a WCO Algorithm in terms of the number of API Calls

WCO Algorithm

Example

Suppose the following query:

```
SELECT ?x ?l ?d WHERE {
  ?x ex:prop1 ex:c1 .
  ?x rdfs:label ?l .
  SERVICE <http://weather.api/request?q={?l}>{
    (["description"]) AS (?d)
  }
  ?x ex:prop2 ex:c2
}
```

WCO Algorithm

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Where the following pattern:

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is empty

WCO Algorithm

Example

The basic algorithm would do **n** calls to the API, but the output of the query is empty!

WCO Algorithm

Example

The basic algorithm would do **n** calls to the API, but the output of the query is empty!

The WCO algorithm selects an order for the variables, and resolves the patterns in such order

WCO Algorithm

Example

Suppose the order of variables `?x`, `?l`, `?d`, then the algorithm evaluates the patterns in the following order

WCO Algorithm

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?x

```
?x ex:prop1 ex:c1 .
?x ex:prop2 ex:c2
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?x, ?l
```

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Now the first pattern throws an empty output before evaluating the SERVICE, and the number of calls is 0

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Recall that the order of appearance of variables is always a feasible one to execute the algorithm

This algorithm stores in cache de JSONs provided by the API, in order to avoid duplicate calls

WCO Algorithm

The algorithm is inspired by the algorithm proposed by AGM, which evaluates a query variable by variable

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$$\varphi_1 = \pi_{A_1}(R_1) \bowtie \ldots \bowtie \pi_{A_1}(R_m)$$

$$\varphi_{j+1} = \varphi_j \bowtie \pi_{A_1,\ldots,A_{j+1}}(R_1) \bowtie \ldots \bowtie \pi_{A_1,\ldots,A_{j+1}}(R_m)$$

WCO Algorithm

Upper bound

Theorem 1. Any feasible query **Q** can be evaluated over any database **D** using a number of calls in

$$O(M_{Q,D} \times 2^{\rho^*(Q,D)})$$

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$2^{\rho^*(Q,D)}$: AGM Bound of the query

WCO Algorithm

Upper bound

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$$O(M_{Q,D} \times 2^{\rho^*(Q,D)})$$

$2^{\rho^*(Q,D)}$: AGM Bound of the query

$M_{Q,D}$: maximum size of the projection of a single attribute over the database

WCO Algorithm

Lower bound

We found a (infinite) family of instances where the bound is reached

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Lower bound

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The algorithm is Worst Case Optimal in terms of API Calls

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We adapted the Berlin Benchmark transforming some sub-patterns into SERVICE-to-API queries

Experiments

Part of the data was exposed into REST APIs

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Three algorithms were tested:

- Vanilla: the basic algorithm
- W/O duplicates: the vanilla algorithm that avoid duplicated calls
- WCO Algorithm

WCO Algorithm

Results

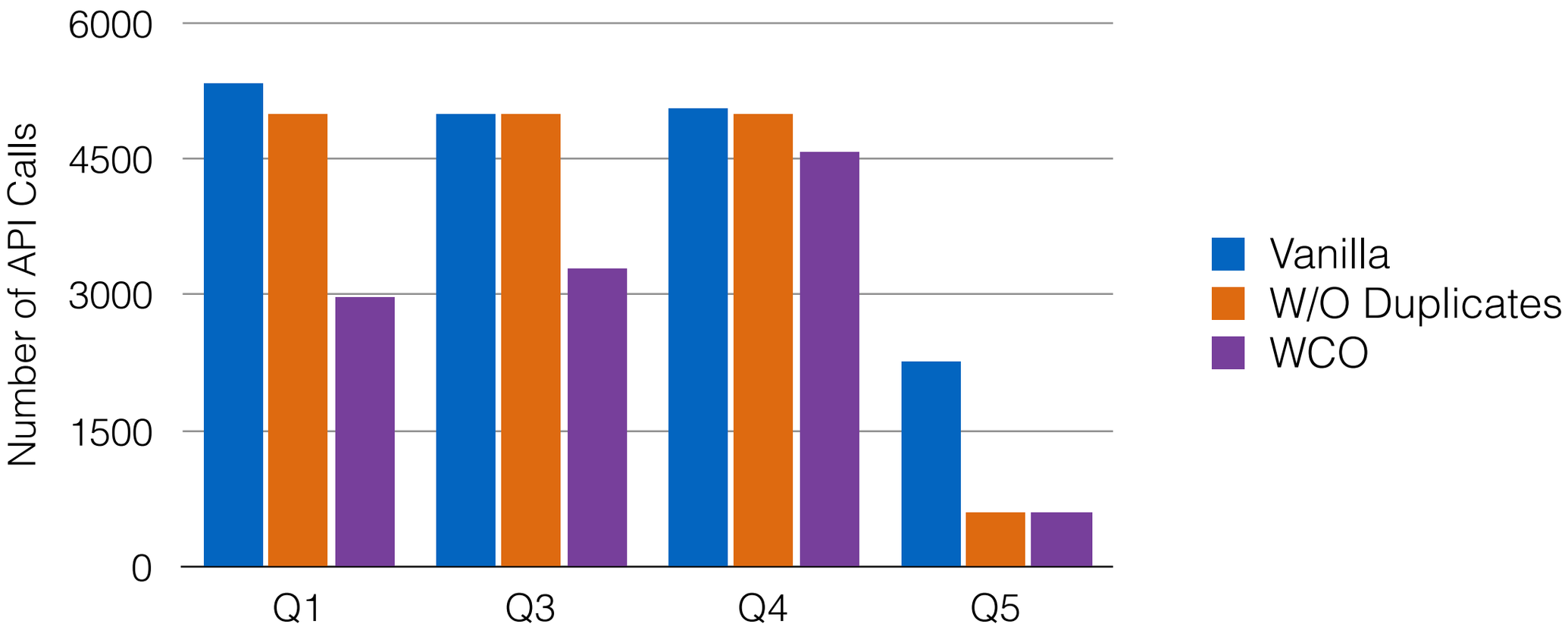

Figure 2: results for the bigger Berlin Benchmark queries

WCO Algorithm

Results

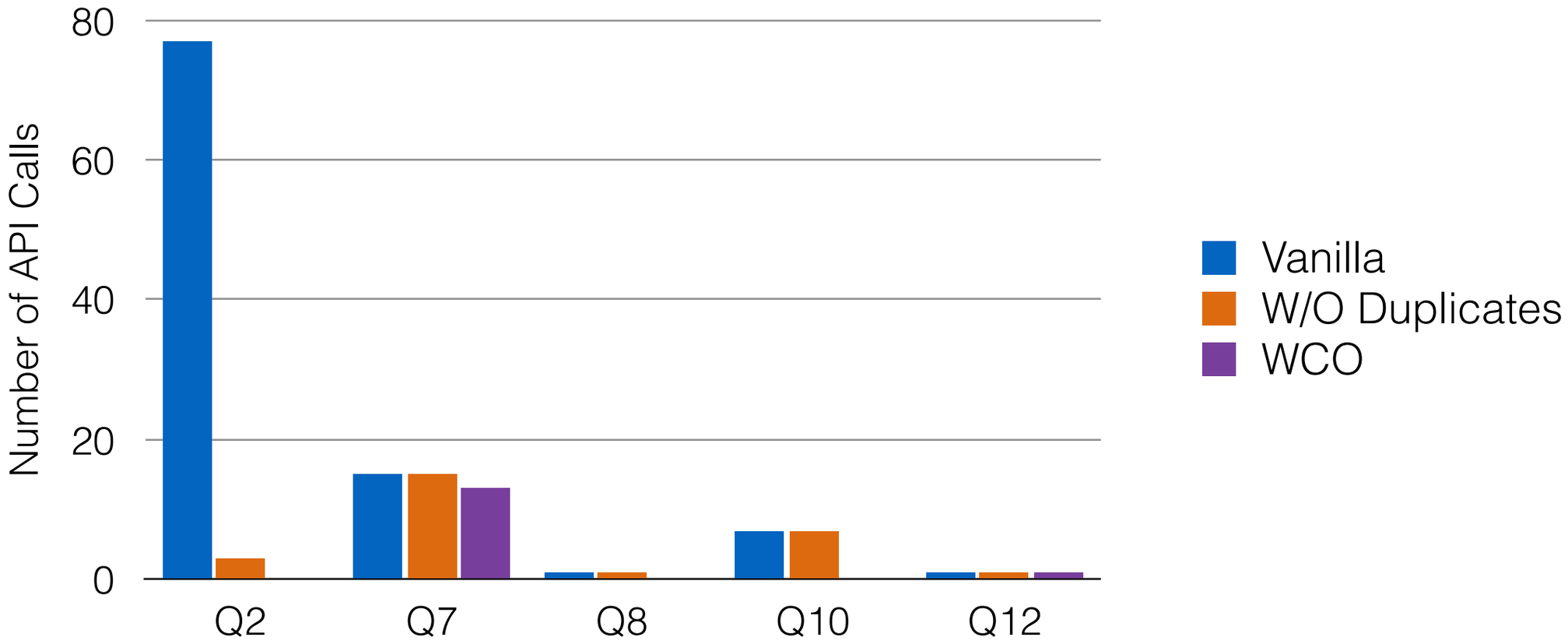

Figure 3: results for the smaller Berlin Benchmark queries

Experiments

The W/O Duplicates algorithm does 20% less calls

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The W/O Duplicates algorithm does 20% less calls

The WCO algorithm does 53% less calls

Outline

Introduction

Preliminaries

SPARQL and JSON API calls

WCO Algorithm

Experiments

Conclusion

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The paper proposed a way to allow SPARQL queries to connect to HTTP APIs returning JSON

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We also proposed a Worst Case Optimal Algorithm to evaluate such queries

Conclusion

Future Work

As future work, we plan to support more formats than only JSON

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As future work, we plan to support more formats than only JSON

We also want to support automatic entity resolution based on an API answer, allowing us to transform API information back to IRIs

Querying APIs with SPARQL: language and worst case optimal algorithms

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