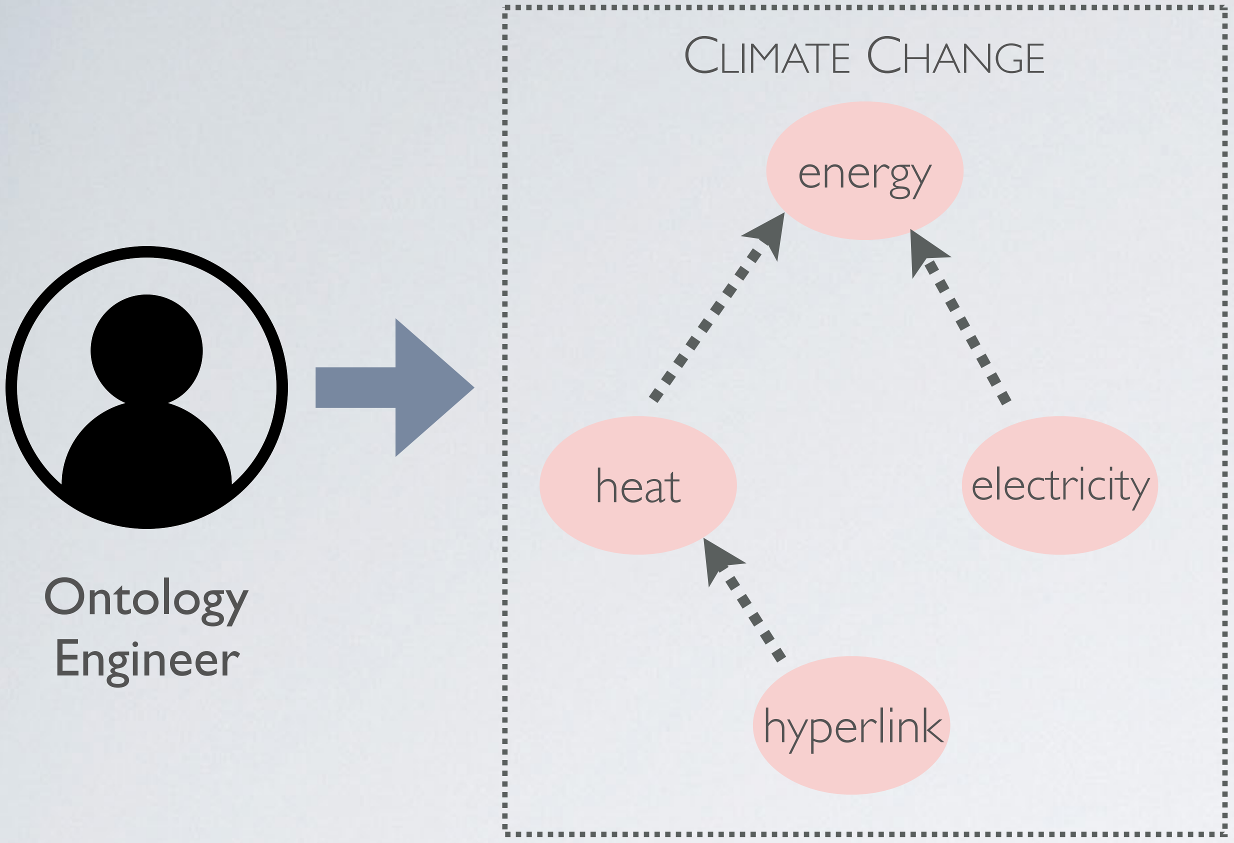
STEFAN GAMERITH

STEFAN GAMERITH

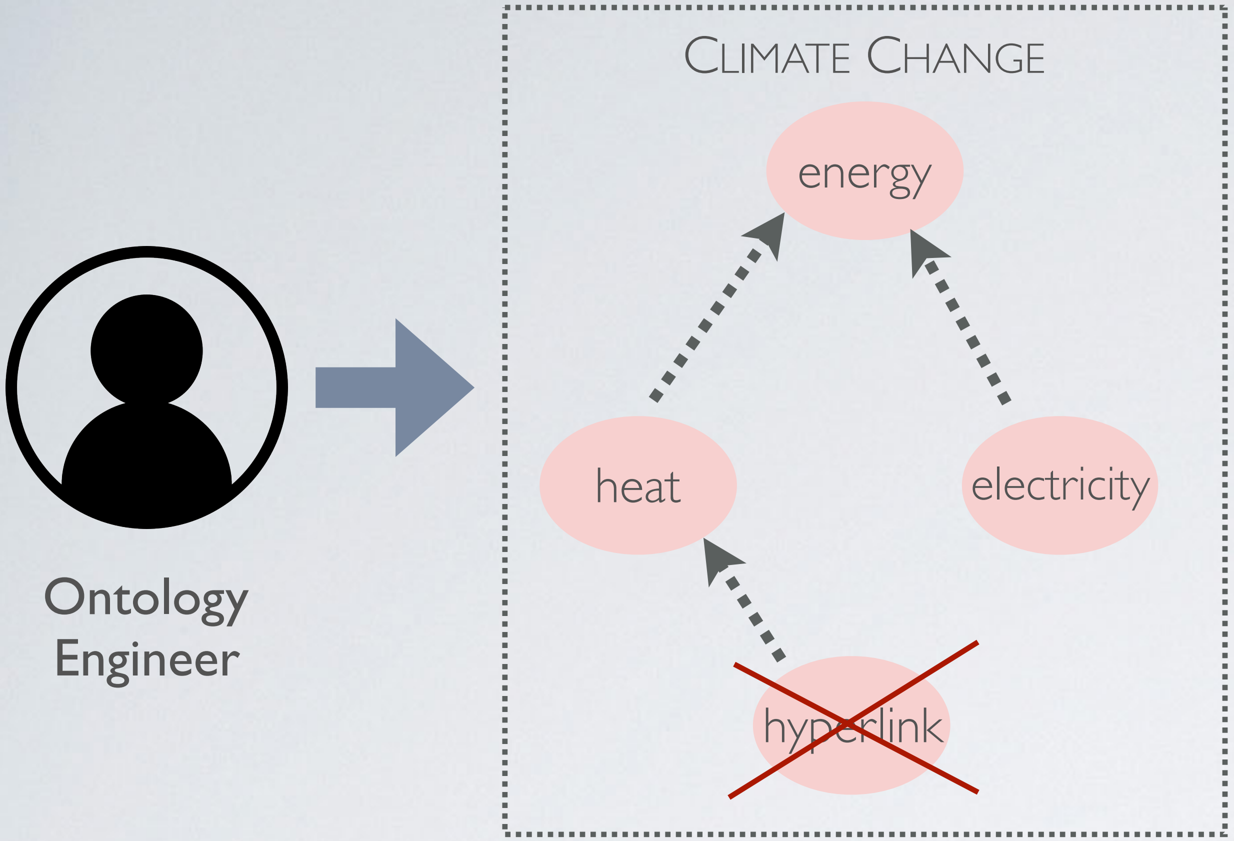
Context Enrichment of Crowdsourcing Tasks for Ontology Validation

Advisor: Ao.Univ.Prof. DI Dr techn. *Stefan Biffl*

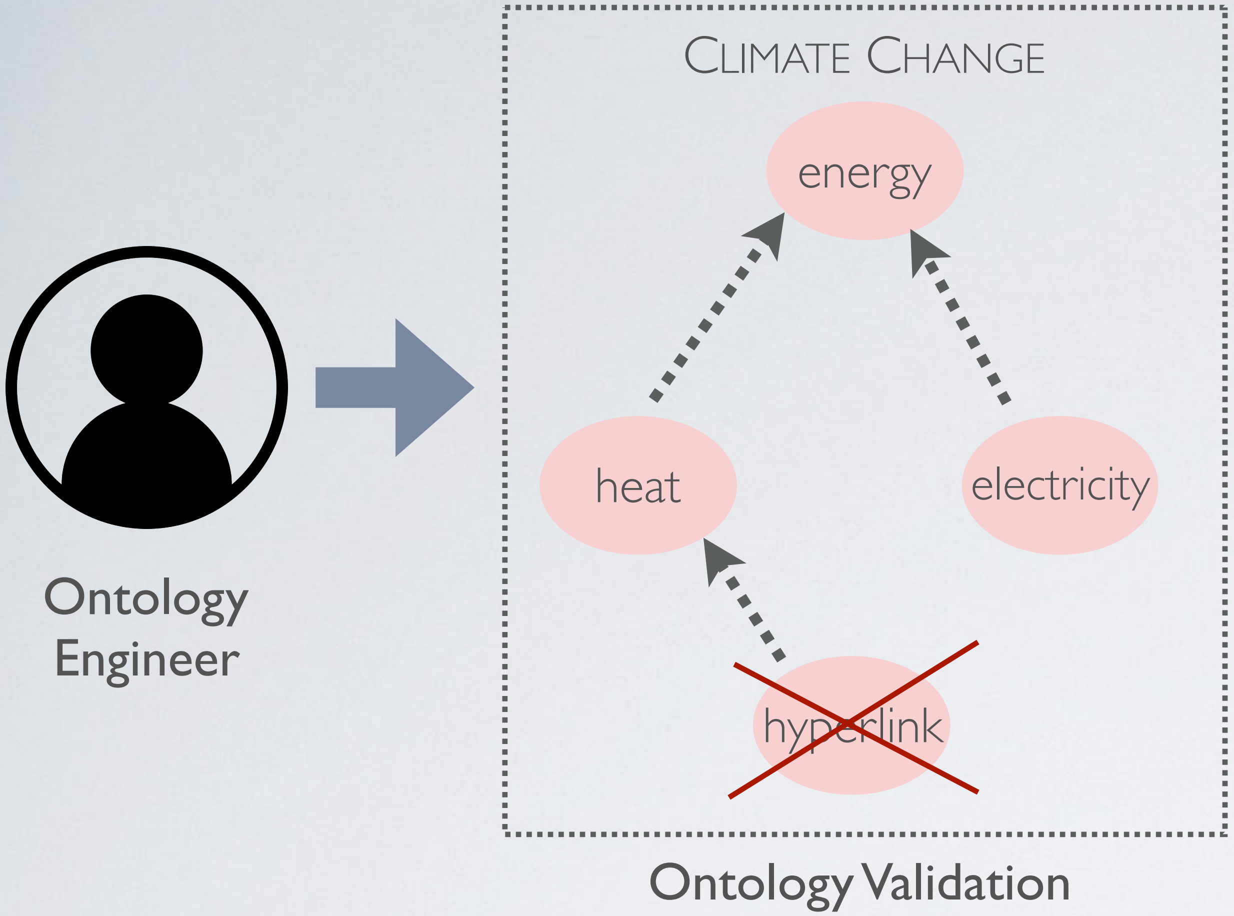
Assistance: *Reka Marta Sabou*, MSc., PhD



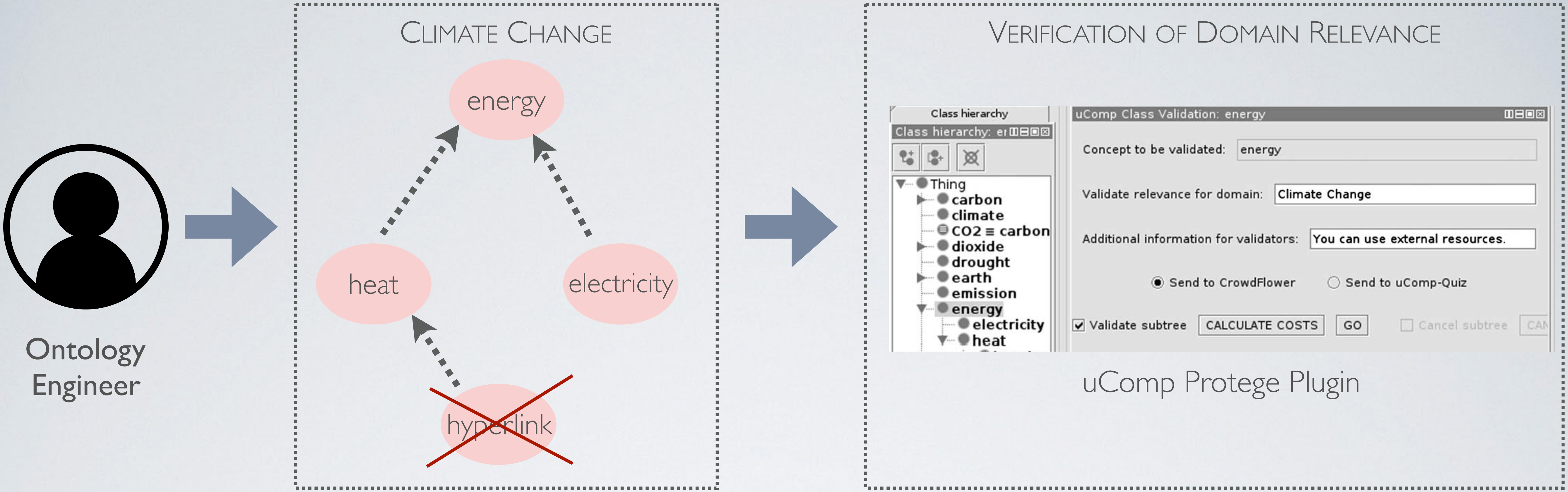
Ontology Validation



Ontology Validation



- expert based validation is costly and time consuming
- crowd-based validation is a cost-effective alternative

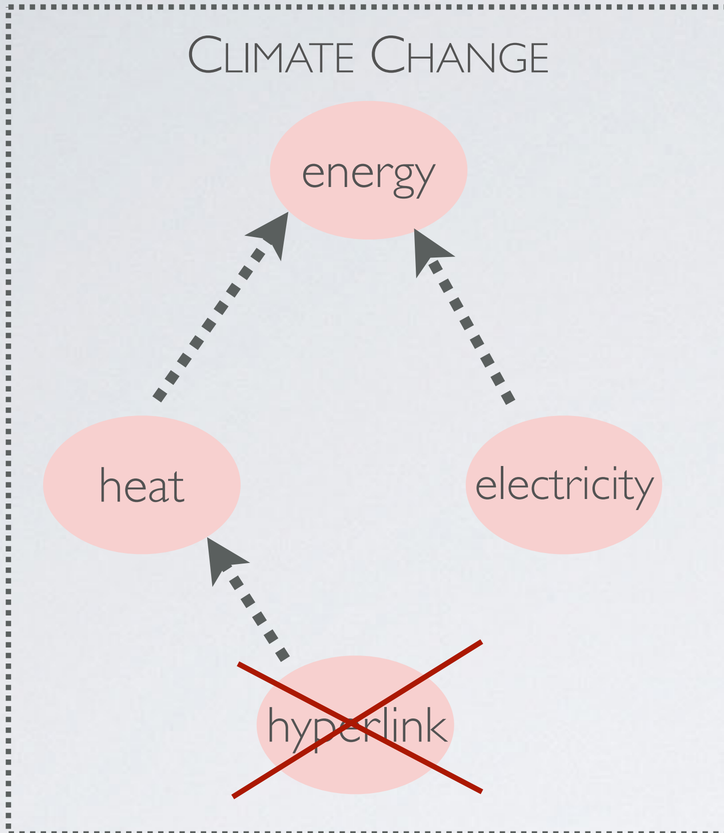


Ontology Validation

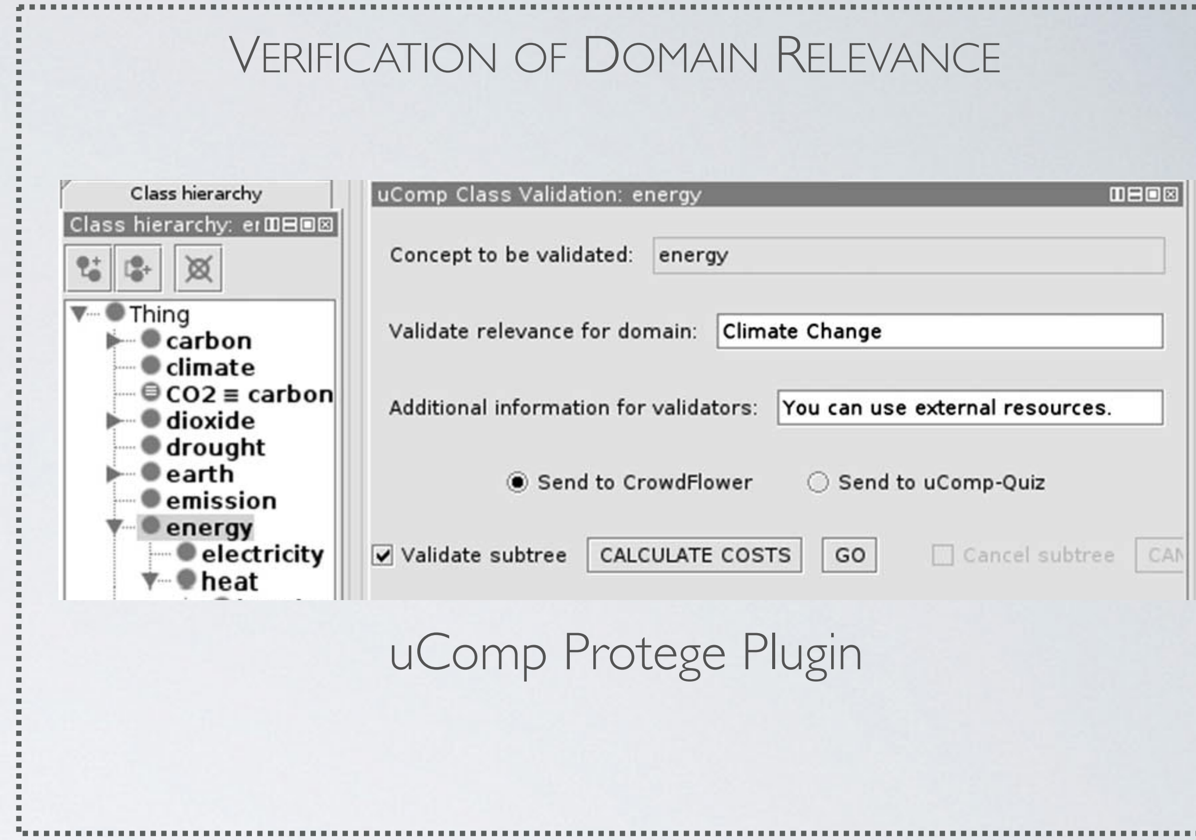
Crowdsourced Ontology Validation

- expert based validation is costly and time consuming
- crowd-based validation is a cost-effective alternative

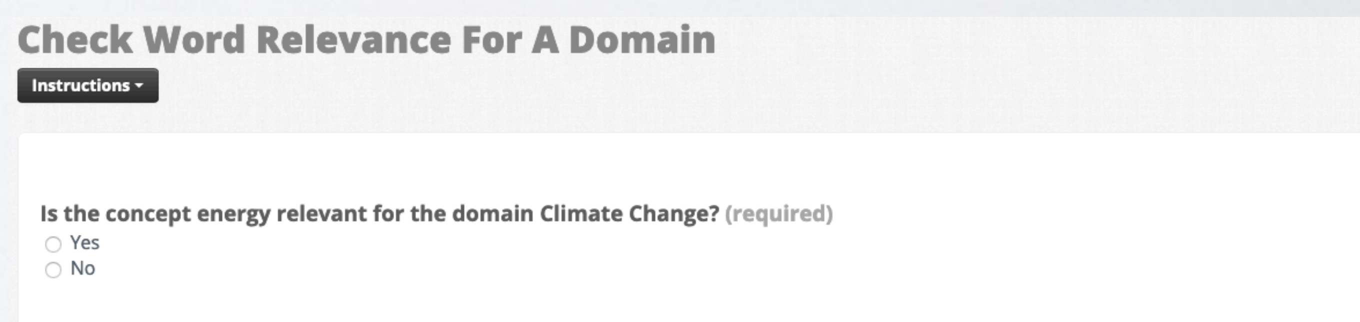
Ontology Engineer



Ontology Validation



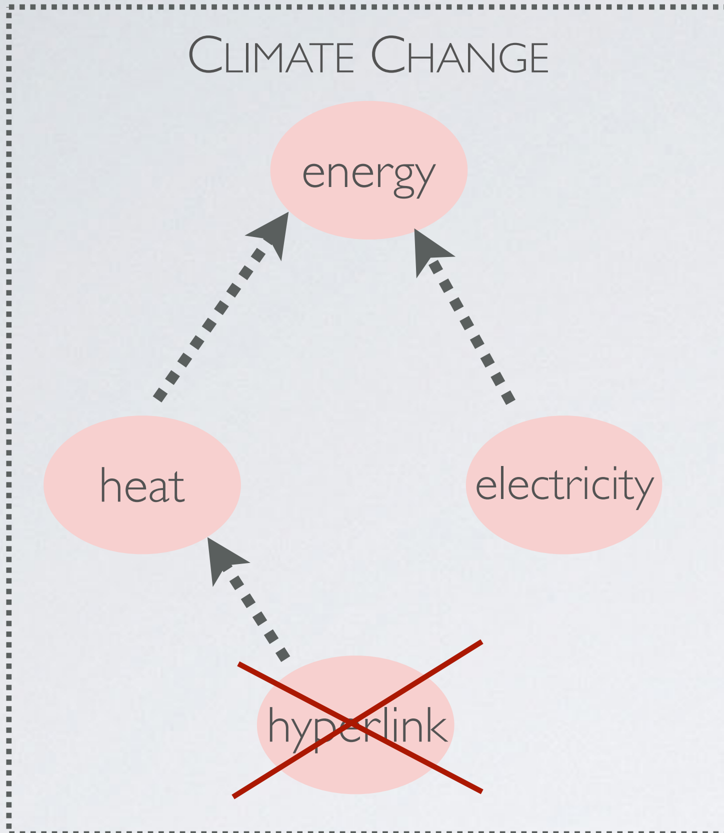
Crowdsourced Ontology Validation



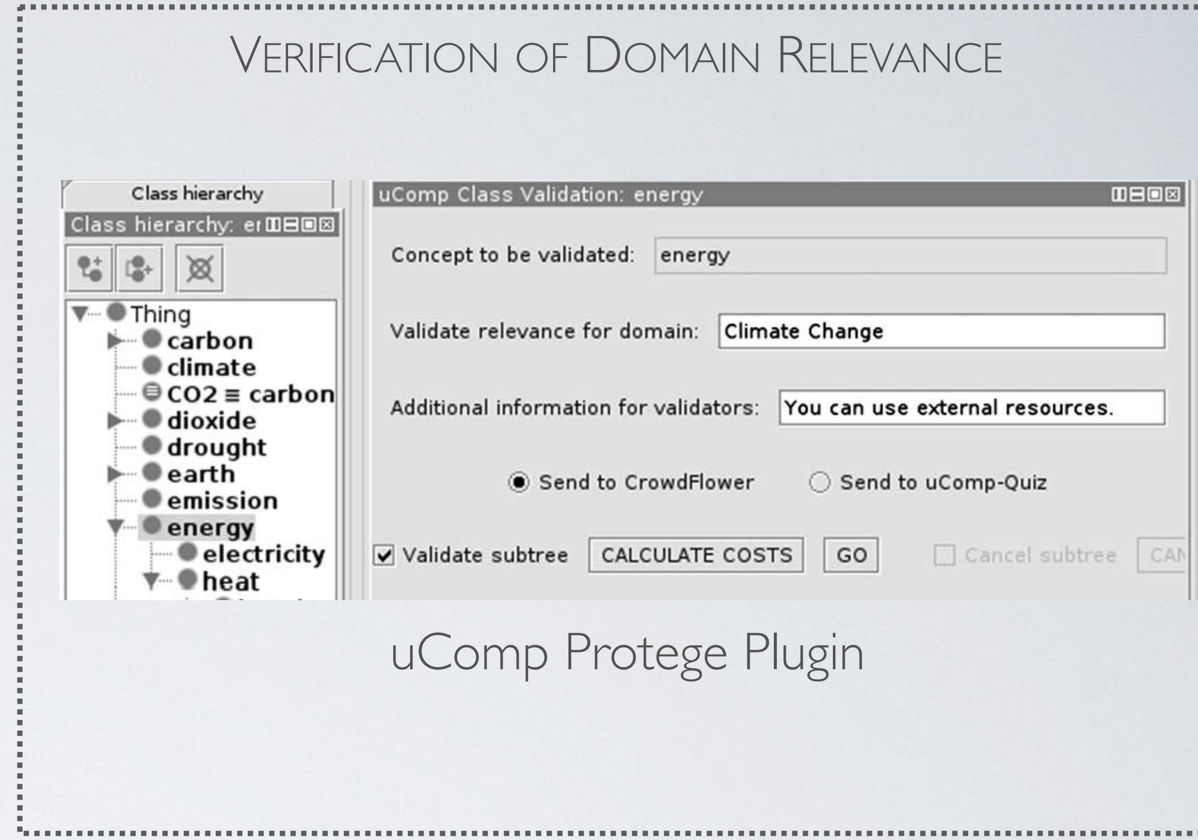
Crowdsourcing Task Interface

- expert based validation is costly and time consuming
- crowd-based validation is a cost-effective alternative

Ontology Engineer

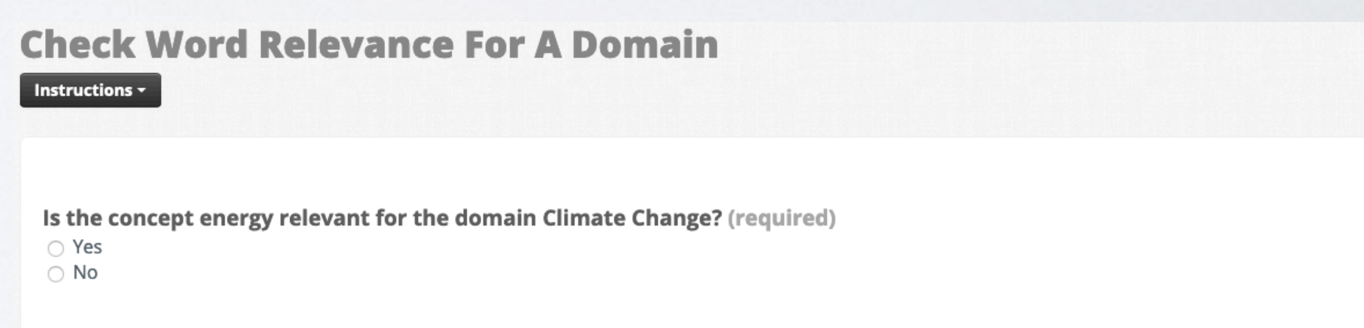


Ontology Validation



Crowdsourced Ontology Validation

- expert based validation is costly and time consuming
- crowd-based validation is a cost-effective alternative



Crowdsourcing Task Interface

Problem: **crowd workers have problems understanding CS tasks because of missing context**

Problem: crowd workers have problems understanding CS tasks because of missing context

Problem: crowd workers have problems understanding CS tasks because of missing context

MISSON: Does the crowd perform better on context enriched CS tasks?

Problem: crowd workers have problems understanding CS tasks because of missing context

MISSON: Does the crowd perform better on context enriched CS tasks?

What methods can be applied that generate context?

RQ 1

Problem: crowd workers have problems understanding CS tasks because of missing context

MISSON: Does the crowd perform better on context enriched CS tasks?

What methods can be applied that generate context?

RQ 1

To what extent is it possible to transfer the investigated methods to different datasets?

RQ 2

Problem: crowd workers have problems understanding CS tasks because of missing context

MISSON: Does the crowd perform better on context enriched CS tasks?

RQ 1	RQ 2	RQ 3
What methods can be applied that generate context?	To what extent is it possible to transfer the investigated methods to different datasets?	Which of the proposed methods works best and what are potential shortcomings?

How to define the notion of Context?

How to define the notion of Context?

Context refers to **any sort of additional information** that is supplied with a Crowdsourcing task to **improve its understanding** in such a way that it positively affects the crowds performance and result quality.

How to define the notion of Context?

Context refers to **any sort of additional information** that is supplied with a Crowdsourcing task to **improve its understanding** in such a way that it positively affects the crowds performance and result quality.

Paper	Evaluated Unit	Context
Acosta et. al.	RDF Triples	Wikipedia Link
Mortensen et. al.	Ontology Structure	Concept Descriptions
Sabou et. al. Winkler et. al.	Conceptual Model	EER Diagram

The use of Context in other Ontology Engineering settings

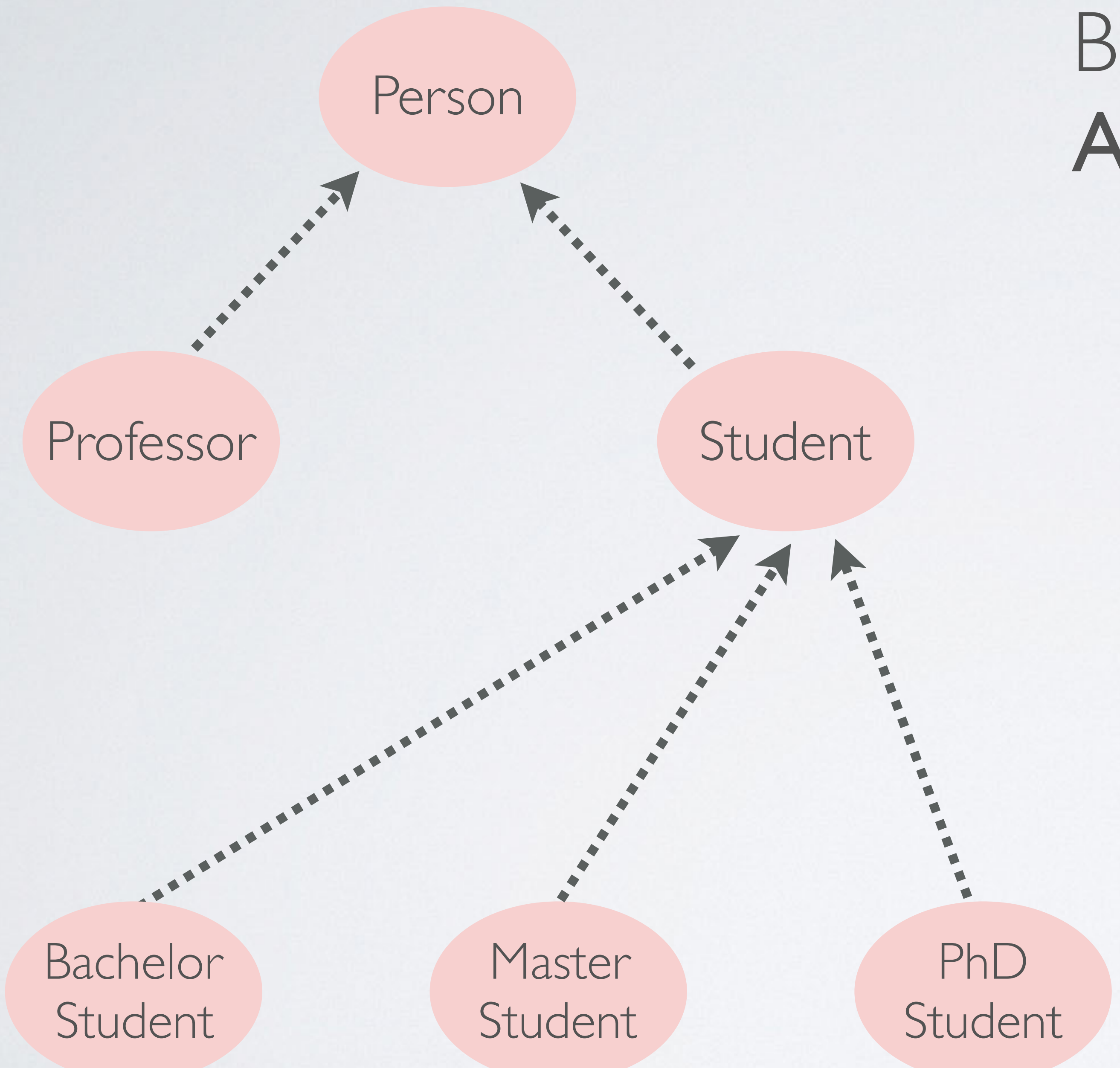
Context Enrichment Methods (RQ 1)

M1： Ontology based Approach

M1： Ontology based Approach

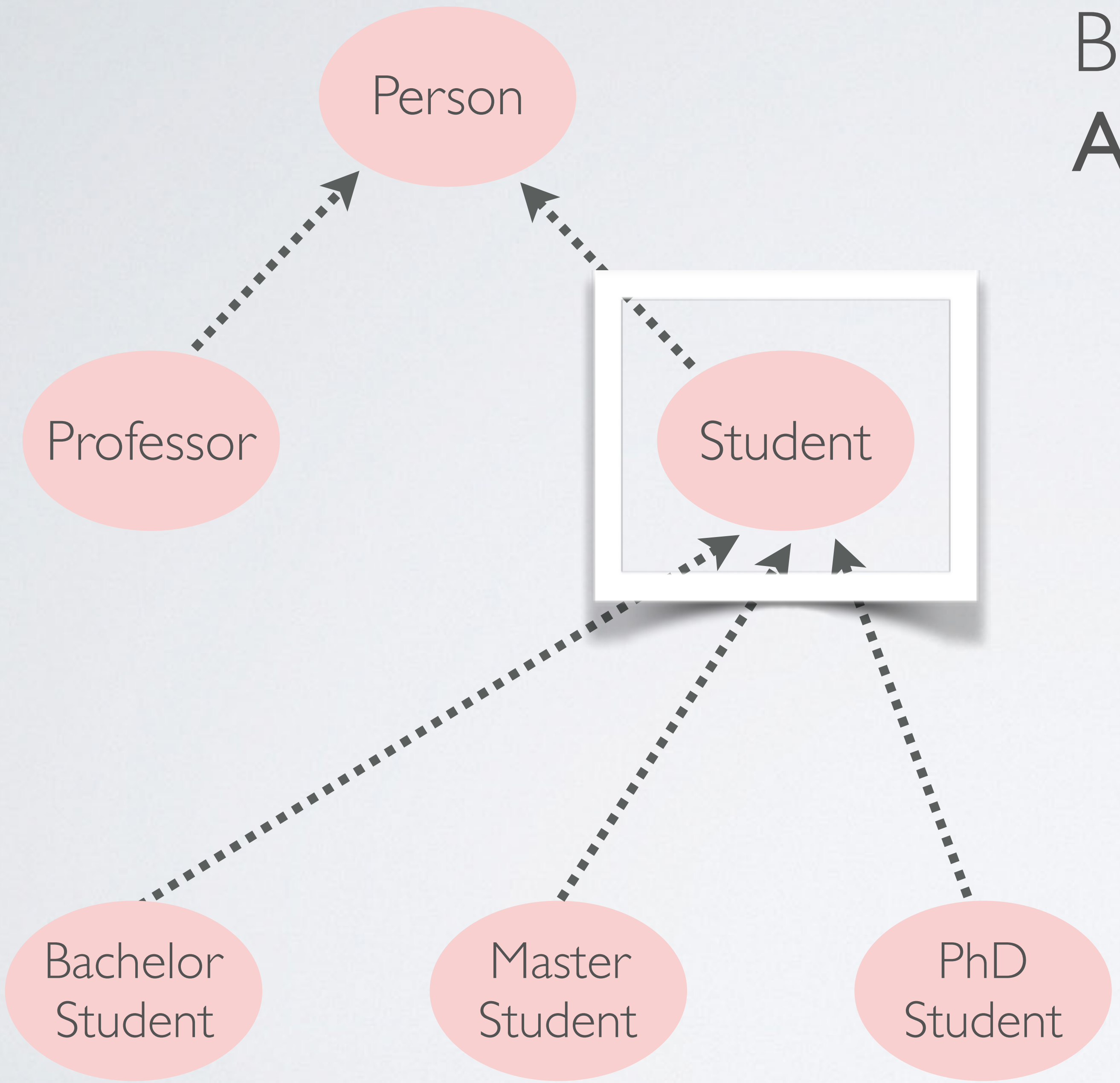
Based on
Attempto **C**ontrolled **E**nglish

M1 :   Ontology based Approach



Based on
Attempto **C**ontrolled **E**nglish

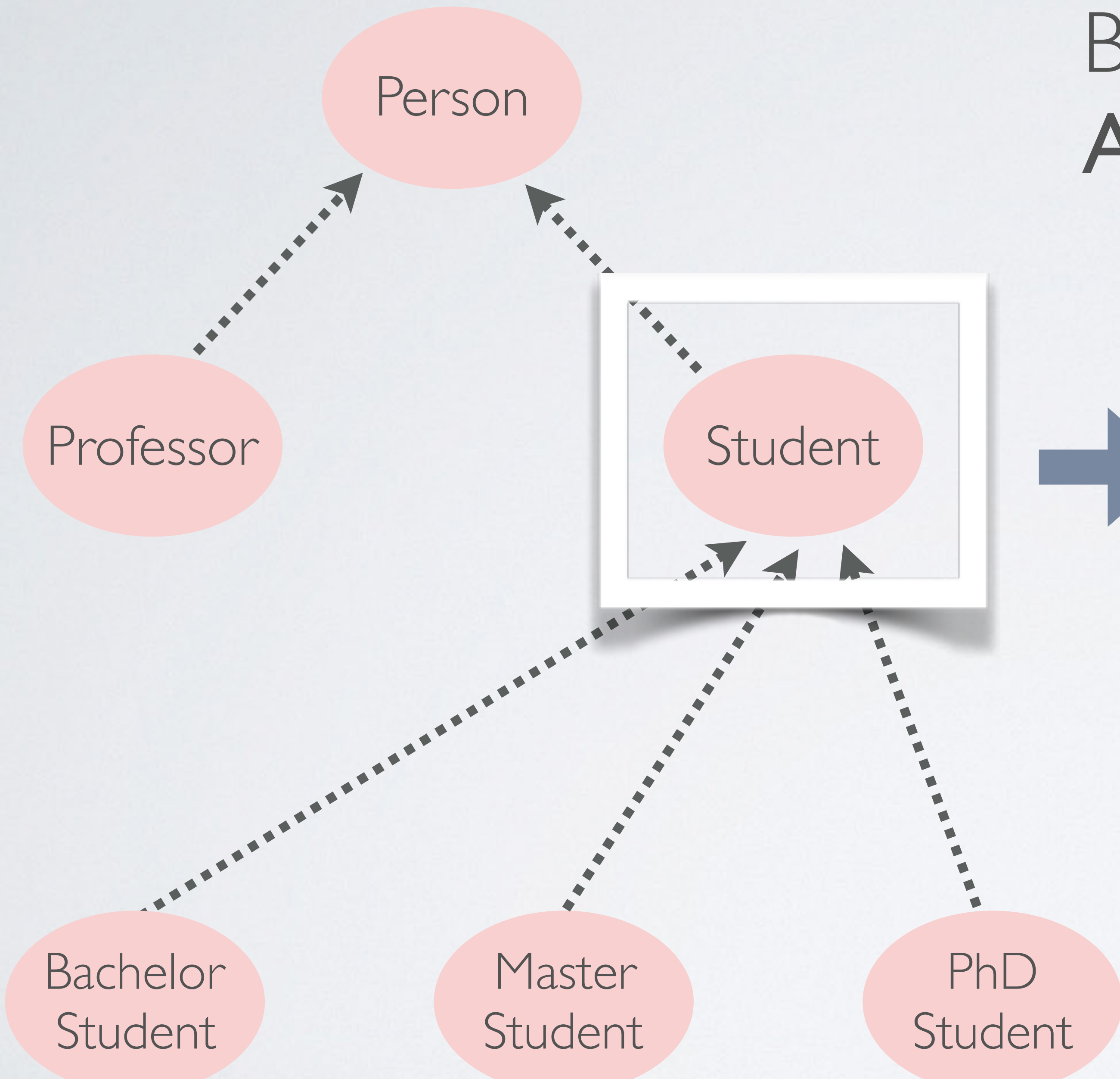
M1 : Ontology based Approach

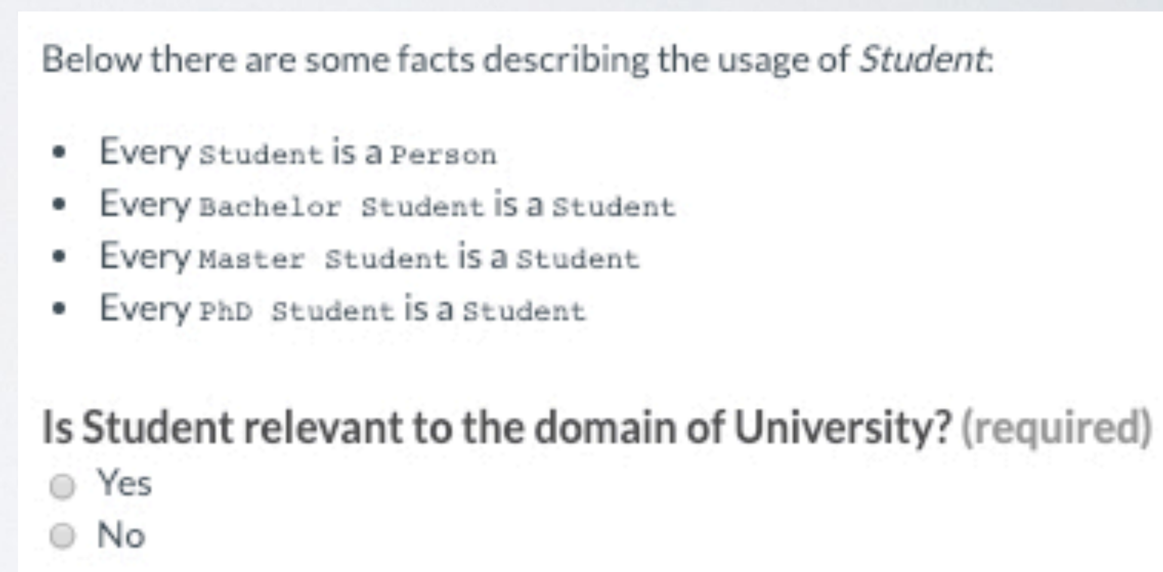


Based on
Attempto **C**ontrolled **E**nglish

M1 : Ontology based Approach

Based on
Attempto **C**ontrolled **E**nglish





Below there are some facts describing the usage of *Student*:

- Every `Student` is a `Person`
- Every `Bachelor Student` is a `Student`
- Every `Master Student` is a `Student`
- Every `PhD Student` is a `Student`

Is Student relevant to the domain of University? (required)

- Yes
- No

M2 :   Metadata based Approach

M2 : Metadata based Approach

```
<rdf>
    <owl:Class rdf:about="http://www.climatechange.org/greenhouse_gas">
        <dc:description>
            Greenhouse gas (GHG) is one of several gases, especially …
        </dc:description>
        <rdfs:label>
            greenhouse gas
        </rdfs:label>
    </owl:Class>
</rdf>
```

M2 : Metadata based Approach

```
<rdf>
    <owl:Class rdf:about="http://www.climatechange.org/greenhouse_gas">
        <dc:description>
            Greenhouse gas (GHG) is one of several gases, especially …
        </dc:description>
        <rdfs:label>
            greenhouse gas
        </rdfs:label>
    </owl:Class>
</rdf>
```

Short Description for *'greenhouse gas'*:

- greenhouse gas

Detailed Description for *'greenhouse gas'*:

- Greenhouse gas (GHG) is one of several gases, especially carbon dioxide, that prevent heat from the earth escaping into space, causing the greenhouse effect. Greenhouse gases from human activities are the most significant driver of observed climate change since the mid-20th century.

Is 'greenhouse gas' relevant to the domain of Climate Change? (required)

- ◯ Yes
- ◯ No

M3 : Dictionary based Approach

M3 : Dictionary based Approach

chartjunk

Concept

M3 : Dictionary based Approach

chartjunk

Concept

Dictionary Lookup

wordnik

M3 :   Dictionary based Approach

M3 : Dictionary based Approach


```
{
   "examples " : [
      {
         ...
         "word": "chartjunk",
         "text": "Marshall described \"chartjunk\" as additional graphics not related to
the data in a quest to make the chart more aesthetically pleasing ." ,
         "title": "Emerson Process Experts"
     },
     ...
   ]
}
```

M3 : Dictionary based Approach

chartjunk

Concept

Dictionary Lookup

wordnik

JSON Response


```
{
   "examples " : [
      {
          ...
          "word": "chartjunk",
          "text": "Marshall described \"chartjunk\" as additional graphics not related to
the data in a quest to make the chart more aesthetically pleasing ." ,
          "title": "Emerson Process Experts"
      },
      ...
   ]
}
```


Example Sentences:

- Emerson Process Experts
  `Marshall described \'chartjunk\' as additional graphics not related to the data in a quest to make the chart more aesthetically pleasing.`

Is chartjunk relevant to the domain of Climate Change? (required)

◯ Yes
◯ No

Experimental Evaluation (RQ 2)

Evaluation Datasets

Evaluation Datasets

	Climate Change	Tennis	Finance
Classes	**101**	**52**	77
Properties	28	34	29
Subclass Relations	84	35	**78**
Individuals	64	33	47

Evaluation Setup

Evaluation Setup

Methods
None Meta, Onto, Dict
None Meta, Onto, Dict
None Meta, Onto, Dict

Evaluation Setup

METHODS	ONTOLOGY
None Meta, Onto, Dict	**Climate Change**
None Meta, Onto, Dict	**Tennis**
None Meta, Onto, Dict	**Finance**

Evaluation Setup

Methods	Ontology	Judgements / Price
None Meta, Onto, Dict	**Climate Change**	5 / 0.05$
None Meta, Onto, Dict	**Tennis**	5 / 0.05$
None Meta, Onto, Dict	**Finance**	5 / 0.05$

Evaluation Setup

METHODS	ONTOLOGY	JUDGEMENTS / PRICE	WORKER SELECTION
None Meta, Onto, Dict	**Climate Change**	5 / 0.05$	Level 3 AUS, UK, USA
None Meta, Onto, Dict	**Tennis**	5 / 0.05$	Level 3 AUS, UK, USA
None Meta, Onto, Dict	**Finance**	5 / 0.05$	Level 3 AUS, UK, USA

Evaluation Setup

METHODS	ONTOLOGY	JUDGEMENTS / PRICE	WORKER SELECTION	QUALITY CONTROL
None Meta, Onto, Dict	**Climate Change**	5 / 0.05$	Level 3 AUS, UK, USA	Quiz
None Meta, Onto, Dict	**Tennis**	5 / 0.05$	Level 3 AUS, UK, USA	Quiz
None Meta, Onto, Dict	**Finance**	5 / 0.05$	Level 3 AUS, UK, USA	Quiz

Aggregated Results over all Ontologies

Aggregated Results over all Ontologies

Method	Precision	Recall	F-Measure
Metadata based Approach	**0,80**	**0,92**	**0,85**
Ontology based Approach	0,79	0,89	0,83
Dictionary based Approach	0,73	0,90	0,81
None	0,67	0,91	0,78

Conclusions

Future Work

Problem: crowd workers have problems understanding CS tasks because of missing context

MISSON:

Impact on the crowd's performance

RQ 1	RQ 2	RQ 3
Context Enrichment Methods	Generalising the Applicability of the proposed Methods	Comparative Analysis of the proposed Methods

Problem: crowd workers have problems understanding CS tasks because of missing context

- the use of context improves the crowd's performance
- results exhibit relatively high recall
- good alternative to expert-based validation

RQ 1	RQ 2	RQ 3
Context Enrichment Methods	Generalising the Applicability of the proposed Methods	Comparative Analysis of the proposed Methods

Problem: crowd workers have problems understanding CS tasks because of missing context

- the use of context improves the crowd's performance
- results exhibit relatively high recall
- good alternative to expert-based validation

M1: Ontology based

M 2: Metadata based

M 3: Dictionary based

RQ 1

Generalising the Applicability of the proposed Methods

RQ 2

Comparative Analysis of the proposed Methods

RQ 3

Problem: crowd workers have problems understanding CS tasks because of missing context

- the use of context improves the crowd's performance
- results exhibit relatively high recall
- good alternative to expert-based validation

M1: Ontology based

M 2: Metadata based

M 3: Dictionary based

RQ 1

M1: Ontology dependent

M 2: Annotation dependent

M 3: Dictionary dependent

RQ 2

Comparative Analysis of the proposed Methods

RQ 3

Problem: crowd workers have problems understanding CS tasks because of missing context

- the use of context improves the crowd's performance
- results exhibit relatively high recall
- good alternative to expert-based validation

RQ 1	RQ 2	RQ 3
M1: Ontology based	**M1:** Ontology dependent	**M1:** works isolated, requires subsumption relations
M 2: Metadata based	**M 2:** Annotation dependent	**M 2:** best performance, requires preprocessing
M 3: Dictionary based	**M 3:** Dictionary dependent	**M 3:** extendable for other providers, sometimes irrelevant results

Future Work

Future Work

- Evaluate the impact of context for other ontology validation tasks

Future Work

- Evaluate the impact of context for other ontology validation tasks
- Combination of context enrichment methods

Future Work

- Evaluate the impact of context for other ontology validation tasks

- Combination of context enrichment methods

- Integration of OWL-Verbalizer

Future Work

- Evaluate the impact of context for other ontology validation tasks
- Combination of context enrichment methods
- Integration of OWL-Verbalizer
- Evaluation of the methods on a larger scale

Thank you

Any questions?

Backup Slides

What is Crowdsourcing?

What is Crowdsourcing?

"Crowdsourcing is the act of taking a task **traditionally performed by a designated agent** and outsourcing it by making an **open call** to an undefined but **large group of people**."

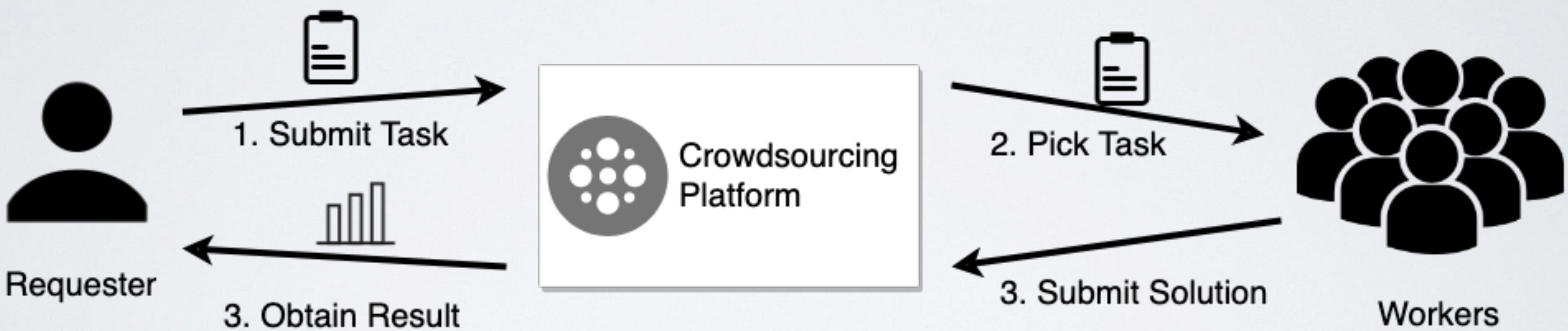
What is Crowdsourcing?

"Crowdsourcing is the act of taking a task **traditionally performed by a designated agent** and outsourcing it by making an **open call** to an undefined but **large group of people**."

Jeff Howe
Wired Magazine - 2006

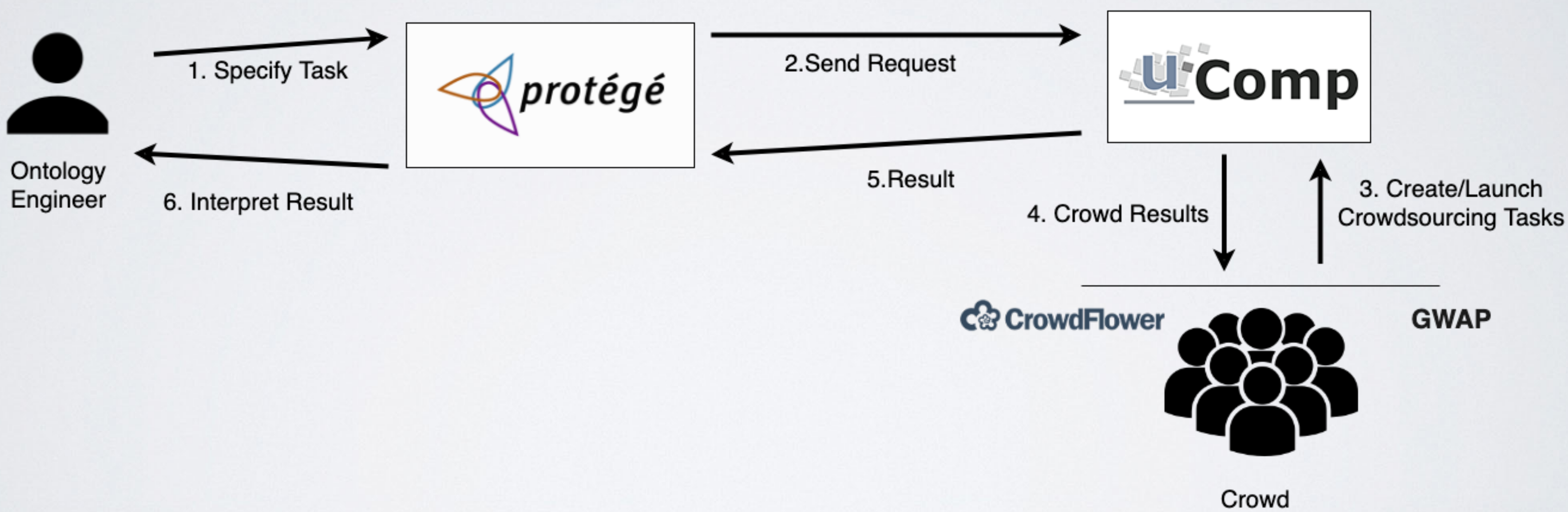
The Stakeholders of the Crowdsourcing Process

The Stakeholders of the Crowdsourcing Process



Crowd-based Ontology Validation Workflow

Crowd-based Ontology Validation Workflow



What is the problem of the Plugin?

"When it comes to the information to be displayed, a challenging aspect is to identify the minimum amount of **Context** […] that contributors need to have to accomplish the task correctly."

Sarasua et. al.
Crowdsourcing and the Semantic Web - A Research Manifesto

Supported Ontology Validation Tasks by the uComp Protege Plugin

Supported Ontology Validation Tasks by the uComp Protege Plugin

1. **Verification of Domain Relevance**

Supported Ontology Validation Tasks by the uComp Protege Plugin

I. Verification of Domain Relevance

II. Verification of Relation Correctness

Supported Ontology Validation Tasks by the uComp Protege Plugin

I. Verification of Domain Relevance

II. Verification of Relation Correctness

   i. Subsumption

Supported Ontology Validation Tasks by the uComp Protege Plugin

I. Verification of Domain Relevance

II. Verification of Relation Correctness

   i. Subsumption

   ii. InstanceOf

Supported Ontology Validation Tasks by the uComp Protege Plugin

I. Verification of Domain Relevance

II. Verification of Relation Correctness

  i. Subsumption

  ii. InstanceOf

III. Specification of Relation Type

Supported Ontology Validation Tasks by the uComp Protege Plugin

I. Verification of Domain Relevance

II. Verification of Relation Correctness

   i. Subsumption

   ii. InstanceOf

III. Specification of Relation Type

IV. Verification of Domain and Range

Context Enrichment Methods

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

The Language Structure of Attempto Controlled English

- **Simple Sentences**

The Language Structure of Attempto Controlled English

- Simple Sentences

  “A customer inserts some cards into a slot.”

The Language Structure of Attempto Controlled English

- Simple Sentences

  "A customer inserts some cards into a slot."

- Composite Sentences

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

- Simple Sentences

  "A customer inserts some cards into a slot."

- Composite Sentences

  "A customer inserts a card **and** the machine checks the code."

The Language Structure of Attempto Controlled English

- Simple Sentences

  “A customer inserts some cards into a slot.”

- Composite Sentences

  “A customer inserts a card **and** the machine checks the code.”

  “It is possible **that** a trusted customer inserts a card.”

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

- Simple Sentences

  "A customer inserts some cards into a slot."

- Composite Sentences

  "A customer inserts a card **and** the machine checks the code."

  "It is possible **that** a trusted customer inserts a card."

  "**Every** card is inserted by a customer."

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

- Simple Sentences

  "A customer inserts some cards into a slot."

- Composite Sentences

  "A customer inserts a card **and** the machine checks the code."

  "It is possible **that** a trusted customer inserts a card."

  "**Every** card is inserted by a customer."

  "**No** customer inserts more than 2 cards."

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

- **Query Sentences**

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

- Query Sentences

  “**Who** inserts a card?”

The Language Structure of Attempto Controlled English

- Query Sentences

  "**Who** inserts a card?"

  "**Which** customer inserts a card?"

The Language Structure of Attempto Controlled English

- Query Sentences

  "**Who** inserts a card?"

  "**Which** customer inserts a card?"

  "**What** does a customer insert?"

The Language Structure of Attempto Controlled English

- Query Sentences

  "**Who** inserts a card?"

  "**Which** customer inserts a card?"

  "**What** does a customer insert?"

  "**When** does a customer enter a card?"

The Language Structure of Attempto Controlled English

- Query Sentences

  “**Who** inserts a card?”

  “**Which** customer inserts a card?”

  “**What** does a customer insert?”

  “**When** does a customer enter a card?”

  “**Where** does a customer enter a card?”

The Language Structure of **A**ttempto **C**ontrolled **E**nglish

- Query Sentences

  “**Who** inserts a card?”

  “**Which** customer inserts a card?”

  “**What** does a customer insert?”

  “**When** does a customer enter a card?”

  “**Where** does a customer enter a card?”

- Anaphoric References

The Language Structure of Attempto Controlled English

- ## Query Sentences

  "**Who** inserts a card?"

  "**Which** customer inserts a card?"

  "**What** does a customer insert?"

  "**When** does a customer enter a card?"

  "**Where** does a customer enter a card?"

- ## Anaphoric References

  "A customer inserts a code. The ATM accepts the card if **the code** is valid."

The Language Structure of Attempto Controlled English

- ## Query Sentences

  "**Who** inserts a card?"

  "**Which** customer inserts a card?"

  "**What** does a customer insert?"

  "**When** does a customer enter a card?"

  "**Where** does a customer enter a card?"

- ## Anaphoric References

  "A customer inserts a code. The ATM accepts the card if **the code** is valid."

  "If a customer owns a card, he inserts **it**."

Algorithm of the Ontology based Approach

Algorithm of the Ontology based Approach

```
Procedure Generate Description
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption
```

Algorithm of the Ontology based Approach

Procedure Generate Description

Input: A concept **C**

Output: A textual description **T** of **C's** neighbouring nodes based on subsumption

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption
---
T = {}
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption

T = {}
for (c, d) ∈ C ⊑ D do
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption
```

```
T = {}
for (c, d) ∈ C ⊑ D do
   T = T ∪ {"Every" ∪ name(c) ∪ "is a" ∪ name(d)}
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption
```

```
T = {}
for (c, d) ∈ C ⊑ D do
   T = T ∪ {"Every" ∪ name(c) ∪ "is a" ∪ name(d)}
for (e, c) ∈ E ⊑ C do
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption

T = {}
for (c, d) ∈ C ⊑ D do
   T = T ∪ {"Every" ∪ name(c) ∪ "is a" ∪ name(d)}
for (e, c) ∈ E ⊑ C do
   T = T ∪ {"Every" ∪ name(e) ∪ "is a" ∪ name(c)}
```

Algorithm of the Ontology based Approach

```
Procedure Generate Description
Input: A concept C
Output: A textual description T of C's neighbouring nodes based on subsumption

T = {}
for (c, d) ∈ C ⊑ D do
   T = T ∪ {"Every" ∪ name(c) ∪ "is a" ∪ name(d)}
for (e, c) ∈ E ⊑ C do
   T = T ∪ {"Every" ∪ name(e) ∪ "is a" ∪ name(c)}
```

What Standards exist to document Metadata?

What Standards exist to document Metadata?

- **Dublin Core Metadata Set**

What Standards exist to document Metadata?

- **Dublin Core Metadata Set**

  Initially contained only 15 terms

What Standards exist to document Metadata?

- **Dublin Core Metadata Set**
    - Initially contained only 15 terms

What Standards exist to document Metadata?

- **Dublin Core Metadata Set**
  - Initially contained only 15 terms

What Standards exist to document Metadata?

- Dublin Core Metadata Set

    Initially contained only 15 terms

- Simple Knowledge Organization System

What Standards exist to document Metadata?

- Dublin Core Metadata Set

  Initially contained only 15 terms

- Simple Knowledge Organization System

  Defines some of RDF properties and RDFS classes

Algorithm of the Metadata based Approach

Algorithm of the Metadata based Approach

```
Procedure Generate Description
```

Algorithm of the Metadata based Approach

```
Procedure Generate Description

Input: A concept C with embedded metadata Φ(C):={m1, m2, . . . , mi}
```

Algorithm of the Metadata based Approach

Procedure Generate Description

Input: A concept **C** with embedded metadata $\Phi(C) := \{m_1, m_2, \ldots, m_i\}$

Output: A description **T** of **C’s** metadata elements

Algorithm of the Metadata based Approach

Procedure Generate Description

Input: A concept **C** with embedded metadata $\Phi(C) := \{m_1, m_2, \ldots, m_i\}$

Output: A description **T** of **C's** metadata elements

Algorithm of the Metadata based Approach

Procedure Generate Description

Input: A concept **C** with embedded metadata $\Phi(C) := \{m_1, m_2, \ldots, m_i\}$

Output: A description **T** of **C's** metadata elements

Algorithm of the Metadata based Approach

Procedure Generate Description

Input: A concept **C** with embedded metadata $\Phi(C) := \{m_1, m_2, \ldots, m_i\}$

Output: A description **T** of **C's** metadata elements

T = {}

Algorithm of the Metadata based Approach

Procedure Generate Description

Input: A concept **C** with embedded metadata $\mathbf{\Phi(C)}:=\{\mathbf{m_1}, \mathbf{m_2}, \ldots, \mathbf{m_i}\}$

Output: A description **T** of **C's** metadata elements

T = {}

for $m_k \in \Phi(C)$ **do**

Algorithm of the Metadata based Approach

Procedure Generate Description

Input: A concept **C** with embedded metadata $\mathbf{\Phi(C)}:=\{\mathbf{m_1}, \mathbf{m_2}, \ldots, \mathbf{m_i}\}$

Output: A description **T** of **C's** metadata elements

T = {}

for $m_k \in \Phi(C)$ **do**

  T = T ∪ m_k

Results

What **Metrics** were used?

What **Metrics** were used?

$$Precision = \frac{TP}{TP + FP}$$

What **Metrics** were used?

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

What **Metrics** were used?

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F - Measure = 2 \cdot \frac{P \cdot R}{P + R}$$

What **Metrics** were used?

$$Precision = \frac{TP}{TP + FP}$$

$$Recall = \frac{TP}{TP + FN}$$

$$F - Measure = 2 \cdot \frac{P \cdot R}{P + R}$$

$$Inter - rater \quad Agreement = \frac{\overline{P} - \overline{P_e}}{1 - \overline{P_e}}$$

What are the Results for the **Climate Change Ontology**?

METHOD	PRECISION
Ontology based Approach	**0,76**
Metadata based Approach	0,73
Dictionary based Approach	0,72
None	0,55

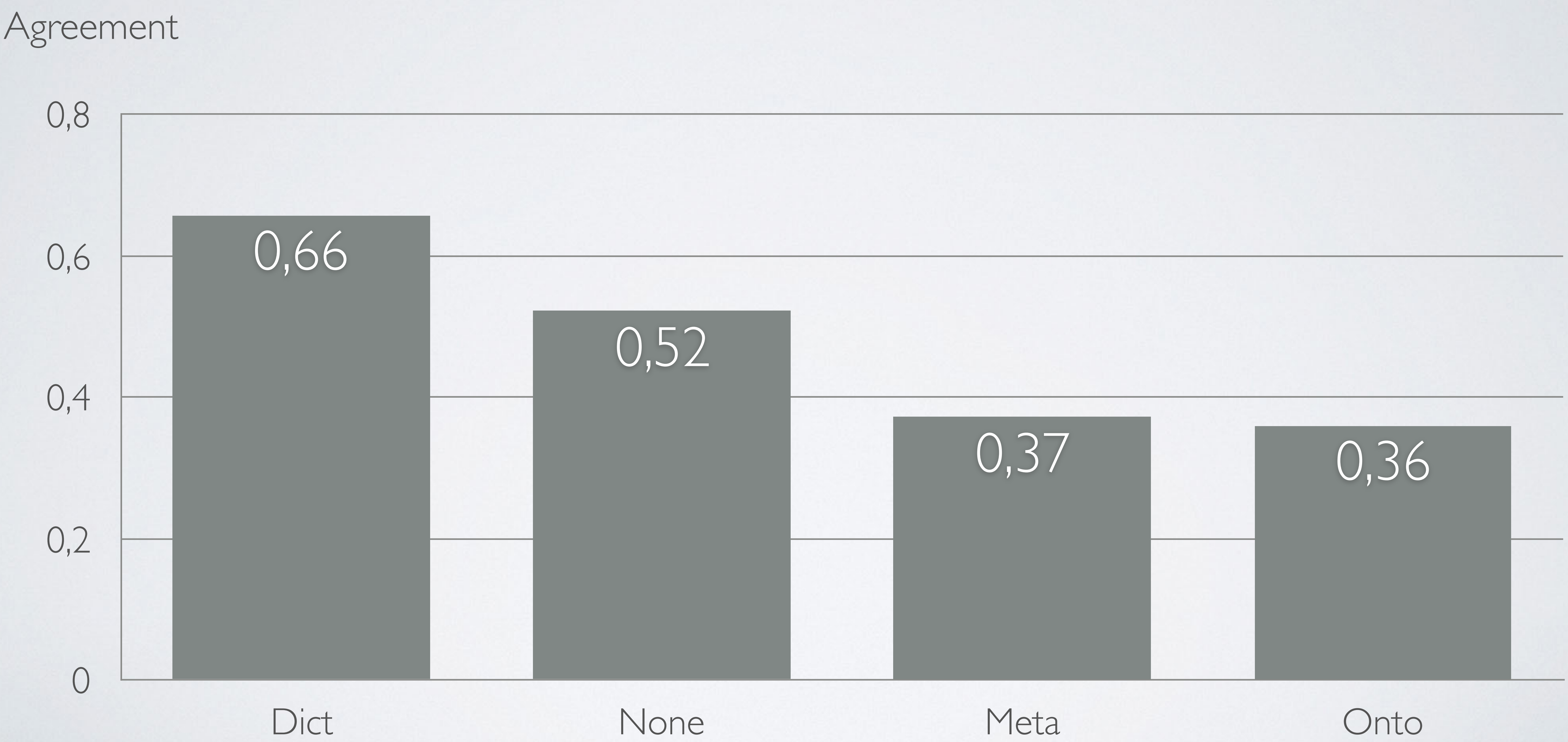
What are the Results for the **Climate Change Ontology**?

METHOD	PRECISION	RECALL
Ontology based Approach	**0,76**	0,81
Metadata based Approach	0,73	0,83
Dictionary based Approach	0,72	0,82
None	0,55	**0,84**

What are the Results for the **Climate Change Ontology**?

Method	Precision	Recall	F-Measure
Ontology based Approach	**0,76**	0,81	**0,78**
Metadata based Approach	0,73	0,83	**0,78**
Dictionary based Approach	0,72	0,82	0,77
None	0,55	**0,84**	0,66

What are the Results for the **Climate Change Ontology**?



What are the Results for the **Finance Ontology**?

METHOD	PRECISION
Metadata based Approach	**0,80**
Dictionary based Approach	0,79
Ontology based Approach	0,76
None	0,73

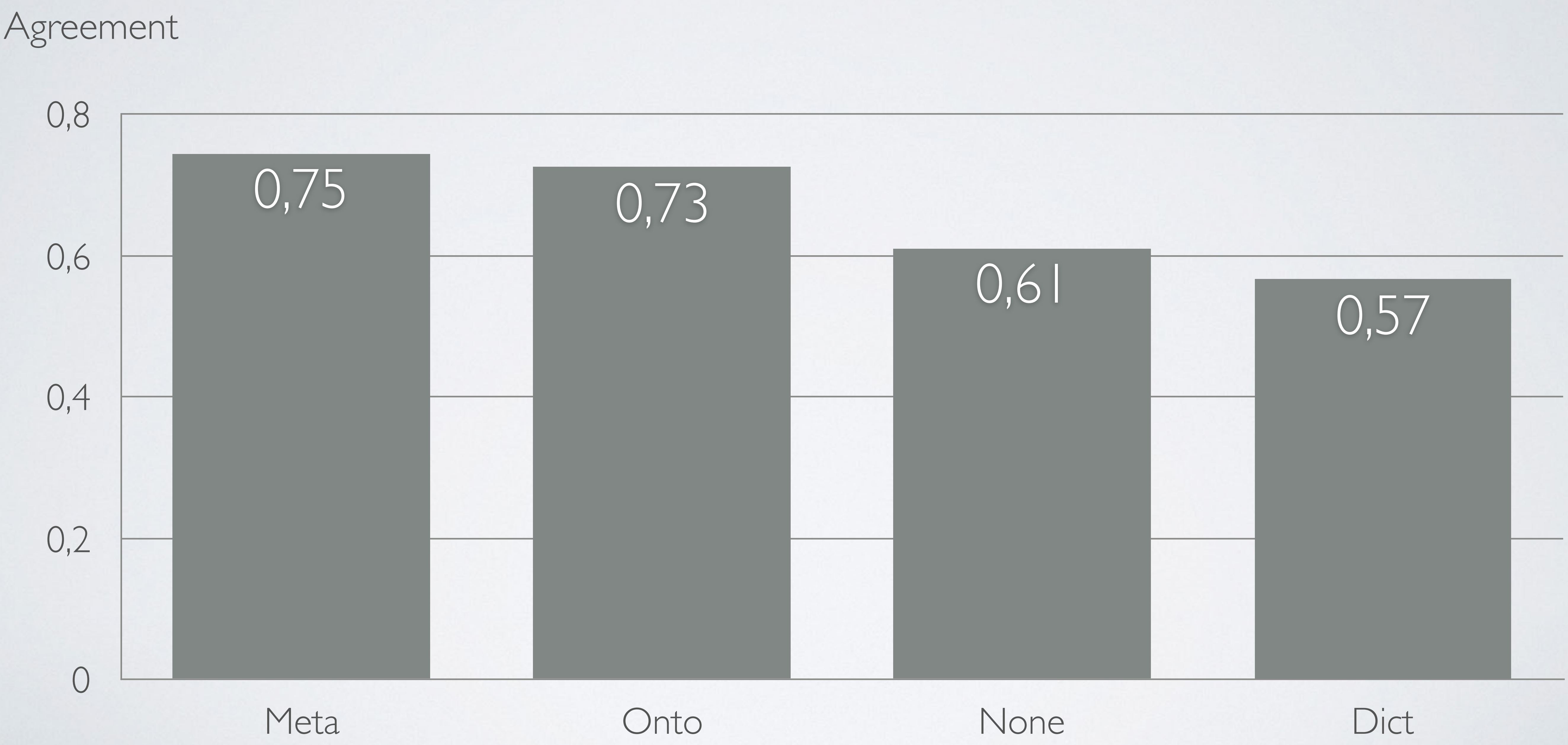
What are the Results for the **Finance Ontology**?

Method	Precision	Recall
Metadata based Approach	**0,80**	**0,99**
Dictionary based Approach	0,79	0,94
Ontology based Approach	0,76	0,95
None	0,73	0,96

What are the Results for the **Finance Ontology**?

Method	Precision	Recall	F-Measure
Metadata based Approach	**0,80**	**0,99**	**0,88**
Dictionary based Approach	0,79	0,94	0,86
Ontology based Approach	0,76	0,95	0,84
None	0,73	0,96	0,83

What are the Results for the **Finance Ontology**?



What are the Results for the **Tennis Ontology**?

Method	Precision
Metadata based Approach	**0,90**
Ontology based Approach	0,87
None	0,78
Dictionary based Approach	0,65

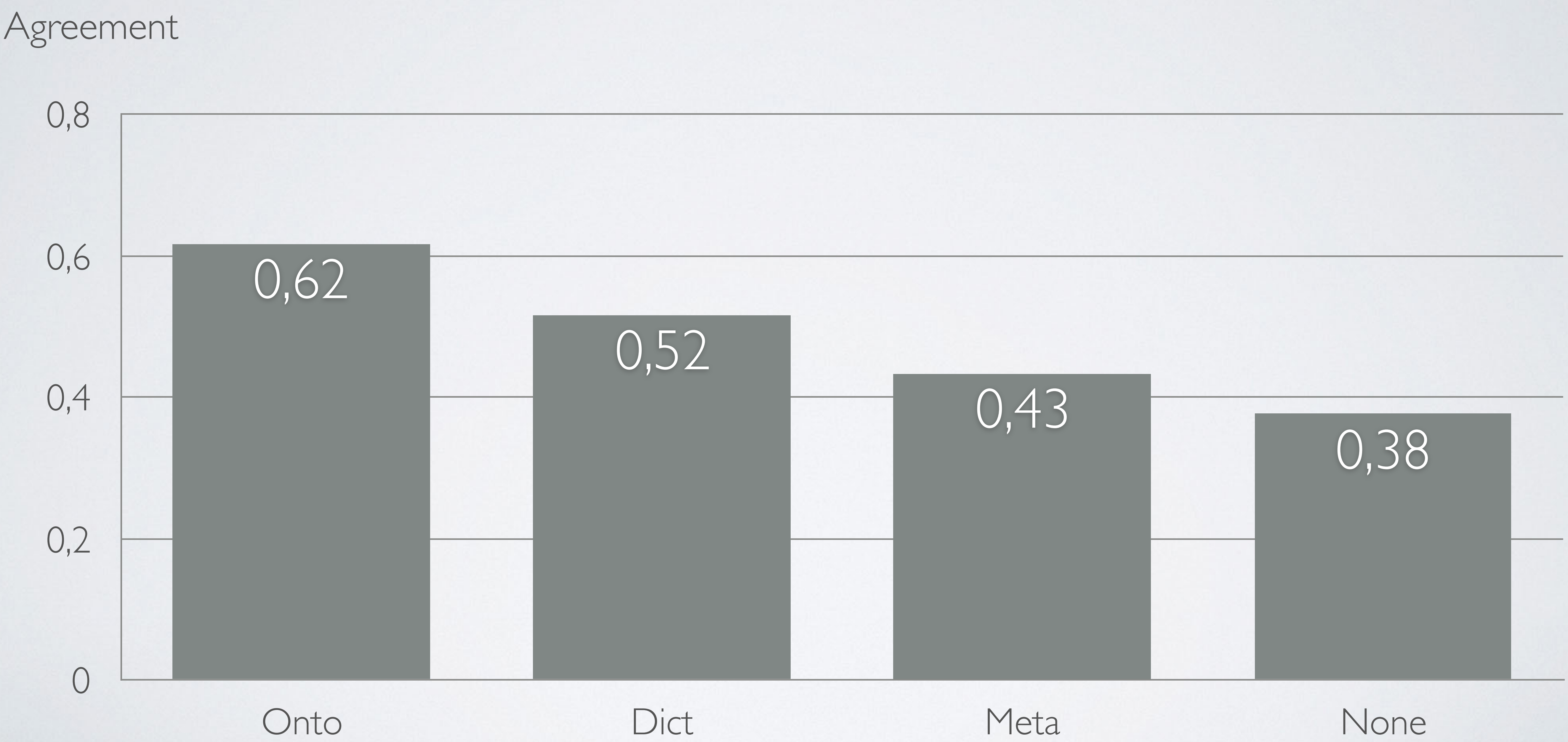
What are the Results for the **Tennis Ontology**?

Method	Precision	Recall
Metadata based Approach	**0,90**	**0,98**
Ontology based Approach	0,87	0,94
None	0,78	0,93
Dictionary based Approach	0,65	**0,98**

What are the Results for the **Tennis Ontology**?

METHOD	PRECISION	RECALL	F-MEASURE
Metadata based Approach	**0,90**	**0,98**	**0,93**
Ontology based Approach	0,87	0,94	0,91
None	0,78	0,93	0,85
Dictionary based Approach	0,65	**0,98**	0,78

What are the Results for the **Tennis Ontology**?



For which Concepts were the Crowd wrong?

Concept	Meta	Onto	Dict	None	Total
sceptic	0/5	0/5	0/5	0/5	0/20
greenhouse	0/5	1/5	0/5	0/5	1/20
pipeline	0/5	0/5	1/5	0/5	1/20
consensus	2/5	0/5	0/5	0/5	2/20
denier	2/5	0/5	0/5	0/5	2/20
production	1/5	1/5	0/5	0/5	2/20

Inter-rater Agreement over all Ontologies