Crowdsourcing Enabled Ontology Engineering

Abstract. Recent years have seen an increase in the use of crowdsourcing-based methods at various stages of the ontology engineering lifecycle (e.g., verification of subsumption, assigning equivalences between concepts etc) thus laying the foundations of a novel approach to ontology engineering (OE). Take up of this early research by the community at large, especially by practitioners, is however currently hampered by 1) a lack of understanding of which stages of the ontology engineering process can be crowdsourced and 2) tool support in ontology engineering platforms that would allow easy insertion of crowdsourcing into ontology engineering workflows. In this paper we perform an overview of recent works in the area and take a scenario-based approach to identifying those stages of the OE process where crowdsourcing makes sense. Then, we present the uComp Protégé plugin, a plugin for the popular Protégé ontology engineering platform that facilitates the integration of crowdsourcing stages into the OE process. TBD: clarify novelty (e.g., which new tasks we introduce?), sum up some important evaluation results.

1 Introduction

[TBD - what is ontology engineering - and how it is always more distributed - WebProtégé, GATE TEamWare - to create semantic annotations on text]

Crowdsourcing techniques allow outsourcing a task to "an undefined, generally large group of people in the form of an open call" [?] and are usually classified in three major genres depending on the motivation of the human contributors (e.g., payment vs. fun vs. altruism). Mechanised labour (MLab) is a type of paid-for crowdsourcing, where contributors choose to carry out small tasks (or micro-tasks) and are paid a small amount of money in return (often referred to as micro-payments). The most popular platform for mechanised labour is Amazon's Mechanical Turk (MTurk) which allows requesters to post their micro-tasks in the form of Human Intelligence Tasks (or HITs) to a large population of micro-workers (often referred to as turkers). Most projects use crowdsourcing marketplaces such as MTurk and CrowdFlower (CF), where contributors are extrinsically motivated through economic incentives. Games with a purpose (GWAPs) enable human contributors to carry out computation tasks as a side effect of playing online games [?]. Finally, altruistic crowdsourcing refers to cases where a task is carried out by a large number of volunteer contributors, such as in the case of the Galaxy Zoo (www.galaxyzoo.org) project where over 250K volunteers willing to help with scientific research classified Hubble Space Telescope galaxy images (150M galaxy classifications).

After concluding that micro-workers are a viable alternative for verifying subclass-superclass relations, Noy and colleagues [**?**] introduce a vision for a tool support that would facilitate the integration of crowdsourcing into OE workflows. [TBD: ZenCrowd and CrowdMap are already approaches that attempt to enable embedded human computation, by making crowdsourcing a part of computational workflow to solve Semantic Web specific tasks such as ontology matching and]. The GATE Crowdsourcing Plugin is a first example of a plugin in a popular toolkit that allows crowdsourcing from within the tool. [**?**]. We present such a tool in this paper, that not only allows the ontology engineer to crowdsource subsumption verification, but also a set of other tasks that often appear in ontology engineering scenarios.

RQ1: Which tasks can be crowdsourced? How do they fit in the OE workflow?

RQ2: How to provide tool support for crowdsourcing in OE?

The contributions of this paper are:

1. We distill a set of common crowdsourcing tasks that are likely to support a variety of ontology engineering tasks.
2. We present a tool, the uComp Protégé plugin, which allows ontology engineers to crowdsource tasks directly from within the popular ontology engineering tool and as part of their ontology engineering workflows.
3. We evaluate some of the functionality of the plugin to estimate the improvements made possible over manually solving a set of tasks in terms of time and cost reductions, while maintaining a similar data quality.

2 Use of Crowdsourcing for Knowledge Acquisition

Crowdsourcing methods have been used to support several knowledge acquisition and, more specifically, ontology engineering tasks. To provide an overview of these methods we will group them along the three major stages of the Semantic Life-cycle as identified by Siorpaes in [**?**], where Stage 1 and 2 cover our notion of ontology engineering [TBD - clarify]. The main points of the following discussion are summed up in Table 1.

Stage 1: Build and maintain Semantic Web vocabularies . Already in 2010, Eckert and colleagues [**?**] relied on MTurk micro-workers in the process of building a concept hierarchy in the philosophy domain. Judgements collected from micro-workers complemented the output of an automatic hierarchy learning method and focused on two main tasks: judging the relatedness of concept pairs (5-points scale between unrelated and related) and specifying the level of generality between two terms (more/less specific than). Noy and colleagues [**?**] focus on the task of verifying subclass-superclass relations that make up the ontology hierarchy as a critical task while building ontologies.

Games with a purpose, have also been used to support the process on ontology creation. OntoPronto game [**?**] aims to support the creation and extension of Semantic Web vocabularies. Players are presented with a Wikipedia page of

an entity and they have to (1) judge whether this entity denotes a concept or an instance; and then (2) relate it to the most specific concept of the PROTON ontology, therefore extending PROTON with new classes and instances. Climate Quiz [**?**] is a Facebook game where players evaluate whether two concepts presented by the system are related (e.g. environmental activism, activism), and which label is the most appropriate to describe this relation (e.g. is a sub-category of). The possible relation set contains both generic (is a sub-category of, is identical to, is the opposite of) and domain-specific (opposes, supports, threatens, influences, works on/with) relations. Finally, Guess What?! [**?**] goes beyond eliciting or verifying relations between concepts and aims to create complex axioms to describe concepts in an ontology. The game explores instance data available as linked open data. Given a seed concept (e.g., banana), the game engine collects relevant instances from DBpedia, Freebase and OpenCyc and extracts the main features of the concept (e.g., fruit, yellowish) which are then verified through the collective process of game playing. The tasks performed by players are: (1) assigning a class name to a complex class description (e.g., assign *Banana* to *fruit&yellow&grows on trees*) and (2) verifying previously generated class definitions.

Stage 2: Align Semantic Web vocabularies The CrowdMap system enlists micro-workers to solve the ontology alignment task [**?**]. It relies on two types of atomic HITS: the first one asks crowdworkers to verify whether a given relation is correct ("Is conceptA the same As conceptB? yes/no "); the second task, requests micro-workers to specify how two given terms are related, in particular by choosing between sameAs, isAKindOf and notRelated. CrowdMap is designed to allow sameAs, subsumption or generic mappings between classes, properties and axioms, but currently it only supports equivalence and subsumption mappings between classes. SpotTheLink is a GWAP that focuses on aligning Semantic Web vocabularies and has been instantiated to align the eCl@ss and UNSWPC [**?**] as well as the DBpedia and PROTON ontologies [**?**]. The final version of the game solves ontology alignment through two atomic tasks: (1) choosing a related concept – given a DBpedia concept they need to choose and agree upon a related PROTON concept; (2) specifying the type of relation between two concepts in terms of equivalence or subsumption.

[TBD if time and place] Community focused efforts in Noy2013

Stage 3: Annotate content and maintain annotations ZenCrowd [**?**] focuses on the entity linking problem, where crowd-workers are used to verify the output of automatic entity linking algorithms. Concretely, given a named entity, e.g., "Berlin", and a set of DBPedia URLs generated automatically, crowd-workers have to choose all the URLs that represent that entity or "None of the above" if no URL is suitable. In essence, this is an annotation task. Who-Knows? [**?**] and RISQ! [**?**] are two games with a purpose which rely on similar mechanisms: they use linked open data (LOD) facts to generate questions and use the answers to (1) evaluate property rankings (which property of an instance

is the most important/relevant); (2) detect inconsistencies; (3) find doubtful facts. The obtained property rankings reflect the wisdom of the crowd and are an alternative to semantic rankings generated algorithmically based on statistical and linguistic techniques. The games differ in the gaming paradigm they adopt. While WhoKnows?! uses a classroom paradigm and aims towards being an educational game, RISQ! is a Jeopardy-style quiz game.

[TBD: More: Celino; Sioarpaes ebay and video annotations]

SW Life-cycle Stage	Approach	Genre	Solved Task
Stage 1: Build and maintain Semantic Web vocabularies	InPho [?]	MLab	(T3) Specification of Relation Type (subs)
			(T1) Specification of Term Relatedness
	Noy [?]	MLab	(T2) Verification of Relation Correctness (subs)
	OntoPronto [?]	GWAP	Class vs. instance decisions
			(T3) Specification of Relation Type (subs/instOf)
	Climate Quiz [?]	GWAP	(T3) Specification of Relation Type (8 relations)
	Guess What?! [?]	GWAP	Verify complex class definitions
			Generate class names for complex defs
Satge 2: Align Semantic Web Vocabularies	CrowdMap [?]	MLab	(T2) Verification of Relation Correctness (subs/eqv)
			(T3) Specification of Relation Type (subs/eqv)
	SpotTheLink [?]	GWAP	(T1) Specification of Term Relatedness
			(T3) Specification of Relation Type (subs/eqv)
Stage 3: Annotate content and maintain Annotations	ZenCrowd [?]	MLab	Text to URL mapping (annotation)
	WhoKnows? [?]	GWAP	Answering quiz questions
	RISQ! [?]	GWAP	Answering quiz questions

Table 1. Overview of crowdsourcing approaches used to address tasks in various stages of the Semantic Web life-cycle [?], their genres and the type of crowdsourcing tasks that they employ.

2.1   Typical Crowdsourcing Tasks in Ontology Engineering

Based on the analysis of the crowdsourcing methods used to support ontology engineering tasks, it emerges that they often converge towards using a range of typical crowdsourcing tasks as follows.

T1. Specification of Term Relatedness. Crowd-workers need to judge whether two terms (typically representing ontology concepts) are related or not. In some cases they are presented with pairs of terms (InPho [?]) while in others they might need to choose a most related term from a set of given terms (SpotTheLink [?]). This type of crowdsourcing task is suitable to be used in diverse ontology engineering stages, for example, both in ontology creation scenarios (InPho [?]) and in ontology alignment ones (SpotTheLink [?]).

T2. Verification of Relation Correctness. Presented with a pair of terms (typically representing ontology concepts) and a relation between these terms, crowd-workers are required to judge whether the suggested relation holds or

not. The majority of work we reviewed report on verifying generic ontology relations such as equivalence [?] and subsumption [?,?], which are relevant both in ontology evaluation [?] and ontology alignment scenarios [?].

T3. Specification of Relation Type. In these kinds of tasks, crowd-workers are presented with two terms (typically corresponding to ontology concepts) and can choose from a set of given relations the relation that best relates the terms. Most efforts focus on the specification of generic ontology relations such as equivalence (Climate Quiz [?], CrowdMap [?], SpotTheLink [?]), subsumption(Climate Quiz [?], InPho [?], OntoPronto [?], CrowdMap [?], SpotTheLink [?]), disjointness (Climate Quiz [?]) or instanceOf (Onto-Pronto [?], Climate Quiz [?]). The verification of domain-specific named relations such as performed by Climate Quiz [?] is less frequent.

T4. Verification of Domain Relevance. For this task, the crowd-workers confirm whether a given term is relevant for a domain of discourse. This task is mostly needed to support scenarios where ontologies are extracted using automatic methods, for example, through ontology learning.

The core crowdsourcing tasks we discuss above have been used by several approaches and across diverse stages of ontology (knowledge) engineering, therefore they are likely to be of interest in a wide range of ontology engineering scenarios. Therefore, they guided the development of our plugin, which currently supports tasks T2 and T4, as well as partially T3.
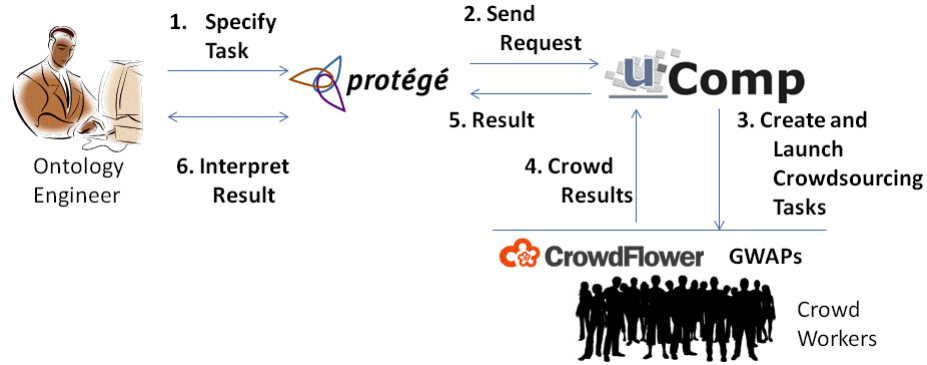
3   The uComp Protégé Plugin

Fig. 1. Main stages when using the uComp plugin.

In order to support ontology engineers to easily and flexibly integrate crowd-sourcing tasks within their ontology engineering workflows, we implemented a crowdsourcing plugin in Protégé, one of the most widely used ontology editors. The typical workflow of using the plugin involves the following main stages (as also depicted in Figure 1).

1. **Task Specification.** An ontology engineer using Protégé can invoke the functionalities of the plugin from within the ontology editor at any time within his current work. The plugin allows specifying some well defined ontology engineering tasks, such as those discussed in Section 3.2 above. The view of the plugin that is appropriate for the task at hand is added to the editor's user interface via the *Window → Views* menu. The ontology engineer then specifies the part of the ontology to verify (eg. a specific class or all classes in the ontology), provides additional information and options in the plugin view and then starts the evaluation. Crowdsourced tasks can be canceled (or paused) anytime during the crowdsourcing process. We further detail the plugin's functionality in Section 3.1.

2. **Task Request** The plugin uses the uComp API[1] to request the processing of the task by the crowd.

3. **Creation of Crowdsourcing Tasks.** The crowdsourcing process happens through the uComp platform[2], a hybrid-genre crowdsourcing platform which facilitates various knowledge acquisition tasks by flexibly crowdsourcing the received tasks to games with a purpose and mechanised labour platforms alike (in particular, CrowdFlower) [**?**]. Depending on user settings, the uComp API delegates the job to a GWAP, to CrowdFlower or to a combination of these two genres. In Section 3.2 we present the crowdsourcing tasks created by the uComp platform.

4&5 **Collection of Crowd Results.** The uComp platform collects and combines crowd-work harvested through various genres and sends the data to the plugin.

6. **Result Presentation and Interpretation.** As soon as available, the plugin presents the results to the ontology engineer and saves them in the ontology. All data collected by the plugin is stored in the ontology in `rdfs:comment` fields, for example information about the ontology domain, the crowdsourcing job ID, and the crowd-created results. Depending on the result, the ontology engineer will perform further actions such as deleting parts of the ontology which have been validated as non-relevant.

3.1   Plugin Functionality

The plugin provides a set of views for crowdsourcing the following tasks:

- Verification of Domain Relevance (T4)
- Verification of Relation Correctness - Subsumption (T2)
- Verification of Relation Correctness - InstanceOf (T2) - the verification of *instanceOf* relations between an individual and a class, i.e. the crowd helps to verify if a given *instanceOf* is valid.

---

[1] TBD: is there an URL for this

[2] The platform is currently being developed as part of the uComp project, `http://www.ucomp.eu/`

- Specification of Relation Type (T3) is a Protégé view component that collects suggestions for labeling unlabeled relations by assigning to them a relation type from a set of relation types specified by the ontology engineer.
- Verification of Domain and Range where crowd workers validate whether a property's *domain* and *range* restrictions are correct. This results in two separate sub-tasks (domain, range). [¡=TBD: what does this do exactly]

In this paper we focus on the description and evaluation of the first two functionalities.
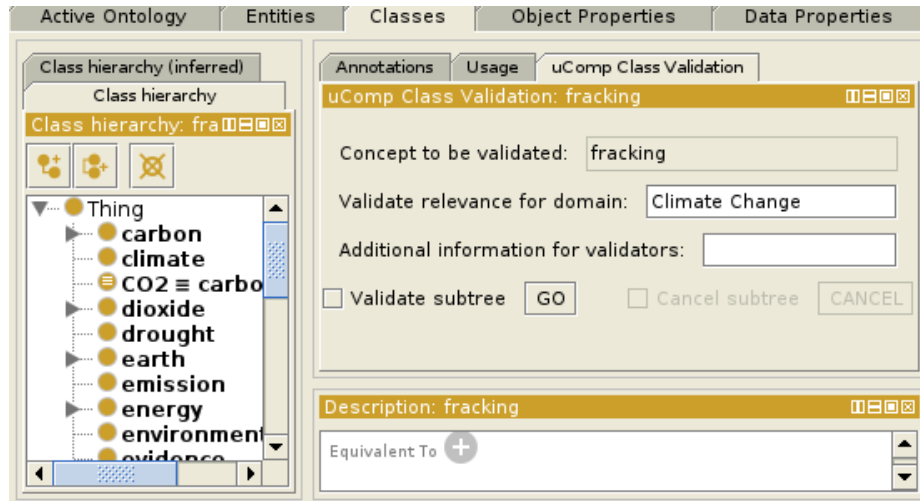

Fig. 2. The interface of the uComp Class Validation view used to create a Verification of Domain Relevance (T4) task. TBD: Gerhard: could you make a new screenshot, with another term that is more know and also shown highlighte in the left side hierarchy list - "climate" would be great. Also, can you add some example text in "Additional information for validators": for example: "You can check any external resources if needed."

Verification of Domain Relevance (T4) is supported by the "uComp Class Validation" view of the plugin and crowdsources the decision of whether a concept (class) is relevant for a domain. First, the ontology engineer adds the corresponding view (*Window → Views → Class Views → uComp Class Validation*) to the editor's UI. Figure 2 shows the screenshot of this view for the class "fracking" before initiating the verification. [TBD - how does the returned result look like? Do we have a screenshot?] The plugin view's interface contains the following information:

Task Specific Information such as the concept selected by the user for validation. This part of the view is diverse among different functionalities.

Generic information such as the *domain* of the ontology, i.e., the field of knowledge which the ontology covers, is present in all views of the plugin. If entered once, the domain will be stored in the ontology (as `rdfs:comment`) and be pre-filled subsequently, but it can also be changed at any time.

Additional information For every task, the plugin contains a predefined task description (typically including examples) which is presented to the crowd-worker. If the ontology engineer wants to extend this task description, (s)he can provide more guidelines in the *additional information* field. This functionality is present in all the views of the plugin.

Recursive control In many cases the ontology engineer wants to perform a task (e.g., domain relevance validation) not only for the current class, but for a larger part of or even the whole ontology. If the *Validate subtree* option is selected, the plugin crowdsources the specified task for the current concept and all its subconcepts recursively. To apply the functionality to the entire ontology, the plugin is invoked from the uppermost class, i.e., (*Thing*).

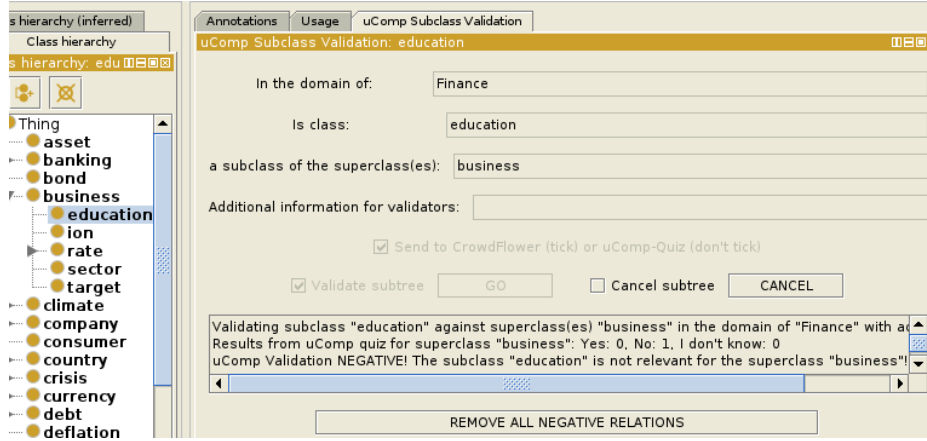`GO` **button** to start the crowdsourcing process.

Fig. 3. Screenshot showing the interface for subClassOf relation validation, including the display of results

.

Verification of Relation Correctness - Subsumption (T2). The second task is the verification of relation correctness, more precisely the verfication of IS-A (subClassOf) relations between classes. The corresponding view is named *Class Views → uComp SubClass Validation*. When selecting a class in Protégé, the plugin automatically detects its superclasses (if any) and fills the boxes in the plugin UI. As soon as results are available these are presented in the UI, as shown in Figure 3. The screenshot gives an example with one evaluator, who rated the *IS-A* relation between "education" and "business" as invalid. As the majority of ratings is negative, a button to remove the relation is displayed.

3.2   Crowdsourcing Task Interfaces

Upon receiving the request from the Protégé plugin, the uComp API selects the appropriate crowdsourcing genres and creates the relevant crowdsourcing jobs. Currently the platform can crowdsource tasks either to games with a purpose such as Climate Quiz or to the CrowdFlower mechanized labour platform. A hybrid-genre crowdsourcing strategy is currently being developed. In this paper, we test the plugin by crowdsourcing only to the CorwdFlower platform.

Figure 4 depicts the crowdsourcing interfaces created automatically by the uComp platform for the two tasks discussed above, namely the verification of domain relevance and the validation of subsumption relations. The uComp platform requires only the task data from the Protégé plugin and it provides relevant instructions as well as gold units to all tasks. Additionally, each crowdsourcing interface is extended with straightforward verification questions (i.e., typing some letters of the input terms) which force crowd-workers to actually read the data of each crowdsourcing unit and therefore take an informed decision rather than just clicking arbitrarily one of the responses.

Fig. 4. Generated CrowdFlower job interface for (a) the Verification of Domain Relevance (T4) and (b) the Verification of Relation Correctness (T2) tasks.

To ensure a good quality output, by default all created jobs are crowdsourced to Level 3 CrowdFlower contributors which are the contributors delivering, on average, the highest quality work. Also, for the moment we assume that the verified ontologies will be in English and therefore we restrict contributors to the main English speaking countries: Australia, United Kingdom and United Sates. In each created job we present 5 units per page and for each unit we collect 5 individual judgements. Future versions of the plugin will provide higher control over task settings from within Protégé.

3.3   Implementation and Installation Details

Protégé was developed in Java, it can easily be extended in the form of *plugins* which are typically Java Archive (.jar) files stored in the Protégé `plugin` directory. The most common form of a Protégé plugin is a *view plugin*, which implements a single view for a specific area of an ontology (e.g. classes, individuals, object properties).

Installation and setup. The plugin has been included into Protégé's central registry and can be installed from within Protégé with the *File → Check for Updates* menu item. A window titled *Automatic Update* will pop up, where you can selected the *uComp Crowdsourcing Validation plugin* from the list of downloads. The download files contain the plugin itself, and a detailed documentation in PDF format. To use the plugin you need to your uComp-API key[3] in a file named `ucomp_api_settings.txt` in folder `.Protege`. Details are found in the plugin documentation.

4   Evaluation

Ontology construction from scratch is a time-consuming and complex process and it is often bootstrapped by re-using existing ontologies or ontologies derived by automatic methods from non-ontological resources (e.g., text corpora, folksonomies, databases etc). Ontology learning methods, for example, automatically extract ontologies from a variety of unstructured and structured resources or a combination thereof. Although the performance of ontology learning methods is improving [Cimiano+Buitelaar], the extracted ontologies typically contain questionable or wrong ontological elements and require a phase of verification and redesign (especially pruning) by the ontology engineer. The ontology verification phase typically involves, among others, checking that the ontology concepts are relevant to the domain of interest and that the extracted subsumption relations are correct. Since the uComp plugin supports both these tasks, we will evaluate these tasks in the scenario of ontology engineering when reusing ontologies obtained through ontology learning.

The ontology learning system used to generate the input ontologies [**?**] is geared towards learning lightweight domain ontologies from heterogeneous sources (text, social media, structured data). The ontology learning process starts from a small seed ontology (typically just a few concepts and relations), and extends it with additional concepts and relations. based on evidence collected from heterogeneous evidence sources with methods such as co-occurrence analysis or Hearst patterns. The neural network technique of spreading activation is the main algorithm used to determine the most important new concepts from the plethora of evidence. After positioning the new concepts in the ontology, the extended ontology serves as new seed ontology, and another round of extension is initiated. The system currently stops after three extension iterations.

4.1   Evaluation Goal

The goal of the evaluation is to assess the improvements that the uComp Plugin could enable in a ontology engineering scenario using ontology learning in terms of typical project completion aspects such as time, cost and quality of output.

---

[3] Request a key from the uComp team, see `http://soc.ecoresearch.net/facebook/election2008/ucomp-quiz-beta/api/v1/documentation/`

The usability of the plugin is an additional criteria that should be evaluated. Concretely, our evaluation goals can be summarised into the following questions:

Time *How does the use of the plugin affect the time needed to perform ontology engineering tasks?* - We distinguish here the total task time (T_{tt}) as the time taken from the start of the ontology engineering task until its finalisation; and the time of the ontology engineer spent actively in the task (T_{oe}). In a crowdsourced scenario, $T_{oe} < T_{tt}$, because the ontology engineer is only actively working during the outsourcing of the task and the review of the result [??]. In contrast, in a traditional scenario $T_{oe} = T_{tt}$. What is of interest to us is the time reduction ratio.

Cost *Are there cost benefits associated with the use of the plugin?* We compute costs related to payments for the involved work-force, that is payments to ontology experts and payments to crowd-workers. Costs of ontology experts are computed by multiplying the time they spend on the task (T_{oe}) with an average salary. In order to allow comparison to other similar cost-focused studies [**?**], the wage of a research scientist was assumed to be \$54,000 per annum.

Quality *What are the implications on the quality of the resulting output when using the Plugin?* Several earlier studies have previously shown that the quality of various knowledge acquisition tasks performed by crowd-workers is, in general, similar to (or even better than) the quality of tasks performed by ontology engineers [**?,?,?**] . While the quality of the obtained data is not the core focus of our evaluation, we expect to obtain results similar to those already published.

Usability *Is the plugin usable?* As any end-user tool, the plugin should be easy to understand and use by the average ontology engineer already familiar with the Protégé environment.

4.2   Evaluation Setup

The setup involves a group of 8 ontology engineers which perform the same tasks over the same datasets but using two different approaches. In the first setting (Setting 1), ontology engineers used the traditional (that is manual) approach to perform the ontology engineering tasks. In Setting 2, the ontology engineers used the Plugin to crowdsource (that is, create and launch) the same ontology engineering tasks. They were given a short tutorial about the plugin (30 minutes) and filled in a short usability questionnaire about using the plugin. The performance of the group in the two diverse settings is then compared along time, cost and quality dimensions.

Evaluation Data The input to all evaluation tasks are ontologies generated by the ontology learning algorithm described above and in [**?**] (primarily) from textual sources. We evaluate the plugin over two ontologies covering two diverse domains (climate change and finance). Table 2 lists some statistics about the sizes of these ontologies.

Nr.	Climate Change Ontology	Finance Ontology
Classes	101	77
Relations	61	50
IsA Relations	43	20
Unnamed Relations	18	30

Table 2. Overview of the ontologies used in the evaluation.

4.3   Evaluation Tasks

We perform the evaluation of the plugin over two different ontology engineering tasks in order to 1) test different functionalities of the plugin; 2) obtain evaluation results over a range of tasks. These tasks are:

Task 1: Check concept relevance for a domain For each concept of the ontology decide whether it is relevant for the domain in question (in our case, climate change and finance). Input: concept (class) and domain name; Output: true/false ratings – we use a uComp_class_relevance annotation in Protégé to save the results – domain experts use true/false

Task 2: Check the correctness of isA relations For all subsumption relations in the ontology verify whether they are correct. Manual experts set the value for a certain annotation uComp_subclassof_check.

4.4   Evaluation Results

For time: For each participant measure Toe, and Ttt, for each task. Compute averages per participant Compute group averages and differences

For costs: Compute avg costs per participant and per group and differences

For quality: Since we do not have a baseline, we will proceed as follows: Task 1: compute pair-wise inter-expert agreement for both groups; and between groups this will measure how different the output is between the plugin and non-plugin group. If it is small then the results are similar; Compute also Cohens Kappa Task 2: same approach as with Task 1 Task 3: Here I think we should evaluate the quality of labels ourselves (em and Gerhard) for each produced ontology; and then compute a precision value

python time_analysis.py 27.375 avg vari 25.234375 stddev 5.02338282435

23.0 avg vari 38.75 stddev 6.22494979899

21.2857142857 avg vari 50.4897959184 stddev 7.10561720883

15.0 avg vari 31.4285714286 stddev 5.60611910581

We have measured inter-rater agreement using the statistical measure of Fleiss' Kappa. Fleiss' Kappa assesses reliability of agreement with a fixed number of raters and categorical ratings assigned to a number of items.

Table 4 presents quality measures .. bla TODO. Inter-rater agreement rates measured with Fleiss' Kappa are consistent and rather high, except for the class relevance verification task for the *Climate Change* ontology. The number of raters

	Climate Change Ontology		Finance Ontology	
	Task 1	Task 2	Task 1	Task 2
Manual validation - AVG time	27.375 (8)	23.0 (8)	21.28 (7)	15.0 (7)
Manual validation - STDDEV	5.023 (8)	6.225 (8)	7.106 (7)	5.610 (7)
CF validation - time				
Time reduction / ratio				

Table 3. Time measures .. TODO.

	Climate Change Ontology		Finance Ontology	
	Task 1	Task 2	Task 1	Task 2
Manual validation	0.338 (8)	0.502 (8)	0.500 (7)	0.388 (7)
Percentage valid − Manual	0.71	0.5	0.72	0.15
Manual + CF (Kappa)		0.527 (9)	0.504 (8)	0.429 (8)
TODO				

Table 4. Quality measures .. TODO.

per task is given in parantheses. TODO refine *Percentage valid* reflects the ratio
of unit where the majority of raters confirm the validity.

```
Usability -- OLGA:
Although I didn't succeed to run the plug-in, i think, i could already answer the questi

1)The documentation was easy to understand.
-> 4, th part about installing plug-in was a bit of mixture with general info about prot
2) The plugin functionality was easy to use.
-> 5 , it is especially good that one can choose to make the check for all ontology at o
3) I would prefer to use the plugin as opposed to doing these tasks manually.
-> 5
4) The use of the plugin saves a lot of time to the ontology engineer.
-> 5
```

5   Conclusions and Future Work

FW:
   1) We need clear methodologies about how to embed crowdsourcing in OE,
similarly to the "annotation science" in NLP
   2) new plugin version will allow greater control over job settings as well as
monitoring the results as they become available from within Protègè.

References

1. K. Bontcheva, I. Roberts, L. Derczynski, and D. Rout. The GATE Crowdsourcing
   Plugin: Crowdsourcing Annotated Corpora Made Easy. In *Proc. of the 14th Con-*

ference of the European Chapter of the Association for Computational Linguistics (EACL). ACL, 2014.

2. G. Demartini, D. E. Difallah, and P. Cudré-Mauroux. ZenCrowd: Leveraging Probabilistic Reasoning and Crowdsourcing Techniques for Large-scale Entity Linking. In *Proceedings of the 21st International Conference on World Wide Web*, pages 469–478. ACM, 2012.

3. Kai Eckert, Mathias Niepert, Christof Niemann, Cameron Buckner, Colin Allen, and Heiner Stuckenschmidt. Crowdsourcing the Assembly of Concept Hierarchies. In *Proc. of the 10th Annual Joint Conference on Digital Libraries*, JCDL '10, pages 139–148. ACM, 2010.

4. J. Howe. Crowdsourcing: Why the Power of the Crowd is Driving the Future of Business, 2009. http://crowdsourcing.typepad.com/.

5. T. Markotschi and J. Völker. Guess What?! Human Intelligence for Mining Linked Data. In *Proc. of the Workshop on Knowledge Injection into and Extraction from Linked Data at the International Conference on Knowledge Engineering and Knowledge Management (EKAW-2010)*, 2010.

6. N. F. Noy, J. Mortensen, M. A. Musen, and P. R. Alexander. Mechanical Turk As an Ontology Engineer?: Using Microtasks As a Component of an Ontology-engineering Workflow. In *Proceedings of the 5th Annual ACM Web Science Conference*, WebSci '13, pages 262–271. ACM, 2013.

7. M. Poesio, U. Kruschwitz, J. Chamberlain, L. Robaldo, and L. Ducceschi. Phrase Detectives: Utilizing Collective Intelligence for Internet-Scale Language Resource Creation. *Transactions on Interactive Intelligent Systems*, 3(1):1–44, April 2013.

8. M. Sabou, K. Bontcheva, A. Scharl, and M. Föls. Games with a Purpose or Mechanised Labour?: A Comparative Study. In *Proc. of the 13th International Conference on Knowledge Management and Knowledge Technologies*, i-Know '13, pages 1–8. ACM, 2013.

9. Marta Sabou, Arno Scharl, and Michael Föls. Crowdsourced Knowledge Acquisition: Towards Hybrid-genre Workflows. *International Journal of Semantic Web and Information Systems*, 9(3):14–41, 2013.

10. C. Sarasua, E. Simperl, and N. F. Noy. CrowdMap: Crowdsourcing Ontology Alignment with Microtasks. In *Proceedings of the 11th International Conference on The Semantic Web - Volume Part I*, ISWC'12, pages 525–541. Springer-Verlag, 2012.

11. A. Scharl, M. Sabou, and M. Föls. Climate Quiz: a Web Application for Eliciting and Validating Knowledge from Social Networks. In *Proceedings of the 18th Brazilian symposium on Multimedia and the web*, WebMedia '12, pages 189–192. ACM, 2012.

12. K. Siorpaes and M. Hepp. Games with a Purpose for the Semantic Web. *Intelligent Systems, IEEE*, 23(3):50 –60, 2008.

13. S. Thaler, E. Simperl, and K. Siorpaes. SpotTheLink: Playful Alignment of Ontologies. In *Proceedings of the 2011 ACM Symposium on Applied Computing*, pages 1711–1712. ACM, 2011.

14. S. Thaler, E. Simperl, and S. Wölger. An Experiment in Comparing Human-Computation Techniques. *IEEE Internet Computing*, 16(5):52–58, 2012.

15. L. von Ahn and L. Dabbish. Designing games with a purpose. *Commun. ACM*, 51(8):58–67, 2008.

16. J. Waitelonis, N. Ludwig, M. Knuth, and H. Sack. WhoKnows? Evaluating Linked Data Heuristics with a Quiz that Cleans Up DBpedia. *Interact. Techn. Smart Edu.*, 8(4):236–248, 2011.

17. G. Wohlgenannt, A. Weichselbraun, A. Scharl, and M. Sabou. Dynamic Integration of Multiple Evidence Sources for Ontology Learning. *Journal of Information and Data Management*, 3(3):243–254, 2012.

18. L. Wolf, M. Knuth, J. Osterhoff, and H. Sack. RISQ! Renowned Individuals Semantic Quiz - a Jeopardy like Quiz Game for Ranking Facts. In *Proc. of the 7th International Conference on Semantic Systems*, I-Semantics '11, pages 71–78. ACM, 2011.