Journal of Advanced Research in Science and Technology
ISSN: 2352-9989

Meaning Negotiation in the Pragmatic Web

Graba Dalila Djoher *, Keskes Nabil and Amar-Bensaber Djamel
LabRi-SBA Lab., Ecole Superieure en Informatique, Sidi Bel Abbes, Algeria

(Received 25 April 2019 - Accepted 21 July 2019 – Published 30 July 2019)

Abstract. Nowadays, the world is undergoing a radical change; everything has become digital. Our daily life is becoming highly linked to computers and the internet; the web technologies allow us to work in collaboration and to share knowledge in a given domain. The pragmatic web became an advanced step in the Web technology. The meaning negotiation is one of the important components in the construction of this web. It is defined as a process of communication that allows the exchange of meaning in people cooperation activities for seeking an agreement.

Keywords: *Meaning Negotiation, Context, Ontology, Pragmatic Web.*

1. Introduction

In many fields, the expansion of resources in the Web makes it difficult to explore and exploit them. Several questions were asked in this direction to resolve this problem. How do the surfers on the Web use the information? How to facilitate the interaction between the surfers? How to return the relevant information?

The Web was extremely effective in providing an unlimited number of people around the world in different fields. It has evolved quickly and become a major technology of the 21st century. Let's start from the beginning, Web 1.0 is a static Web, centered on the distribution of information (e-mails, content portals). However, this Web did not stay constant because of the information changes. In the early 2000s, Web 2.0 also called the Social Web. This latter favors the dimension of sharing and exchanging information and content (texts, videos, images…). The Web 3.0 named Semantic Web is appreciated at the beginning of 2010, it provides a basis for intelligent applications that enable more efficient use of information by providing a collection of knowledge with meaningful content and a logical additional structure. The Semantic Web, with all its advantages, still poses several difficult challenges. The more the Semantic Web becomes widely usable by humans, the more social and human requirements and constraints become difficult. The human factor in the Semantic Web is an unresolved problem [1]. However, the Pragmatic Web has emerged to resolve the limits of the Semantic Web.

Meaning Negotiation is the key factor in the construction of the Pragmatic Web. It allows users to share common objectives and concepts part of pragmatic resources for communication. The problem of meaning negotiation is between two domains of artificial intelligence (AI) and knowledge representation (KR). However, there are different ways of representing knowledge (logic, ontology, etc.), hence the problem of heterogeneity. So, to have a powerful meaning negotiation, it is necessary to present the knowledge in a clear and unambiguous way to use it in the meaning negotiation.

The model of [2] is a process scenario of meaning negotiation in the Pragmatic Web. This model represents the knowledge of each communicating part by the context to deal with the problem of the Semantic Web. The case study of [3] adopted this model and succeeded to improve meaning negotiation with ontologies merging (contextual and domain ontologies). They compare the meaning negotiation process with and without merging according to the step numbers.

* Dalila Djoher Graba.
E-mail: d.graba@esi-sba.dz.
Address: LabRi-SBA Lab., Ecole Superieure en Informatique, Sidi Bel Abbes, Algeria.

It will be more interesting to compare the two processes according to the run time. The main objective of the paper is to attain a meaning negotiation scenario more simplified and reduced in the Pragmatic Web. This will minimize the mentioned problems of the Semantic Web.

2. Pragmatic Web

The Web represents a symbolic system, and its symbols are the content of the Web page and the tags (Syntax). This symbol will be interpreted by agents to enable the machines to exploit the information on the Web (semantic, pragmatic). In philosophy, pragmatic comes from the Greek word [pragma] meaning action. It was introduced by Peirce in 1878 in "How to make our ideas clear". In Computer Science, "The Pragmatic Web consists of tools, practices, and theories describing why and how people use information." [4]. The Pragmatic Web deals not only with the form or meaning of information but with the social interaction that brings. It encourages the development of knowledge in communities of interest and practice. Many definitions have been proposed:

- According to Moris Charles 1946 the Pragmatic "Deals with the origins, uses, and effects of signs in the total behavior of sign interpreters."
- According to [1], the Pragmatic Web is on how to make Web technology (semantics) to serve people to collaborate in their disorder, real world, the evolution of the domains of interaction.
- According to [2], "The Pragmatic Web is a set of pragmatic contexts of semantic resources."
- According to [5], the Pragmatic Web is the best hope for the Semantic Web to encourage the emergence of communities of interest and practice that develop their own consensus knowledge on the basis of which they will normalize their representations.

To conclude, the Pragmatic Web is the extension of the Semantic Web, which allows a community of practice or interest to negotiate for agreement developing their common knowledge.

2.1. Meaning negotiation

Meaning negotiation in the Web is done in the control environment where the user context is known, the user action can be traced, and the user communication can be captured. It is the general process with which agents reach agreement on the meaning of a set of terms. The authors in [6] defined meaning negotiation as a learning process among community members through textual or verbal discourse, textual comments on specific learning objects such as policies, rules, statements, news, or collaborative conception and development of a team's products.

For example, consider two agents a buyer agent and a seller agent to negotiate the selection of one or more audiovisual product (television). The content of the negotiation is the set of possible television from which a television can be selected. If the software agents use words that have the same meaning, the negotiation this time is in the semantic rather than on the television. For example, if the agents negotiate the price, an agent that uses the word price and the other use raises total to designate the price these words are different in syntax but it still represents the same concept.

2.1. Context and Contextual Ontology

The context is a factor of communication, which acts on the meaning of a message and on the relations between the different parts of the message. The most commonly used definition is that of [7]. They defined the context as any information used to characterize the situation of an entity (person, physical object or computer). The context is the environment that surrounds and contains the entity. This environment makes it possible to characterize a situation that can subsequently influence the behavior of the entity.

Context modeling is widely recognized as a context representation. There are several context modeling techniques used in contextual computing. Among them, we quote the model-oriented ontology.

Ontology plays a key role in sharing a common understanding and appears to be the most promising solution for sharing information both semantically and pragmatically. Contextualization consists of allowing the partitioning of ontology according to their context in a different domain. Contextual ontologies are ontologies that vary according to the context in which a concept is characterized by a set of properties.

3. State of art

Several approaches have been proposed to improve meaning negotiation in the Pragmatic Web. The approaches will be classified into four groups according to the context representation: logic, ontology, neural network models, and hybrid. The classification will go further where the classes are divided into two subclasses according to the form of negotiation be an auction or argument basis. The auction is become democratized on the internet through sites like EBay, Yahoo auctions. Argument-based negotiation is used in logical agents that have a knowledge base with predicates and inference rules.

3.1. Ontology Context Model

The approaches use ontologies to model the context. It represents a conceptual group in a well-defined field and relations between concepts.

Auction

Using NLP Techniques for Meaning Negotiation: This approach was presented in [8], introduced an algorithm for an automated meaning negotiation that allows semantic interoperability (Find matches) between local ontology and heterogeneous ontology for different autonomous communities. To find the match, the approach has proposed a scenario of several steps:

- The linguistic and semantic analysis of a single label that appears in the ontology by the use of natural language processing and lexical database (Wordnet).
- Define the contextual meaning of a concept by considering the context to which the label belongs.
- Find the matches between the source concepts and the target concept.

In the linguistic label analysis, the use of a semantic dictionary improves and disambiguates concepts meaning. The semantic label analysis makes it possible to eliminate irrelevant concepts in a context and verify the coherence between global knowledge of concepts and structural information from the context. Consider two label types; one for concepts and one for relations. The approach focused on merging concepts labels, leaving aside relations labels.

Ontology-guided meaning negotiation in communities of practice: This mechanism was designed in [9] to improve and resolve communication ambiguities in meaning negotiations between communities. The DOGMA framework in Figure 1 disposes an ontology server which contains a lexicon base and commitments server. It is extended with a layer of community modeling process that allows the analysis of problems, needs and meaning negotiation between members. The community modeling process forms a link between ontology engineering process and community modeling through meaning negotiation. The engineering must be independent of the community context to agree.

In communities of practice, many ambiguities of communication arise when communities become important and distributed. To solve this ambiguity problem and improve the communication, the use of ontology can play an instrumental role in making meaning negotiation more effective and decisive. The negotiation process becomes complex when the community of practice is especially large in the step of interaction with the ontology engineering layer.

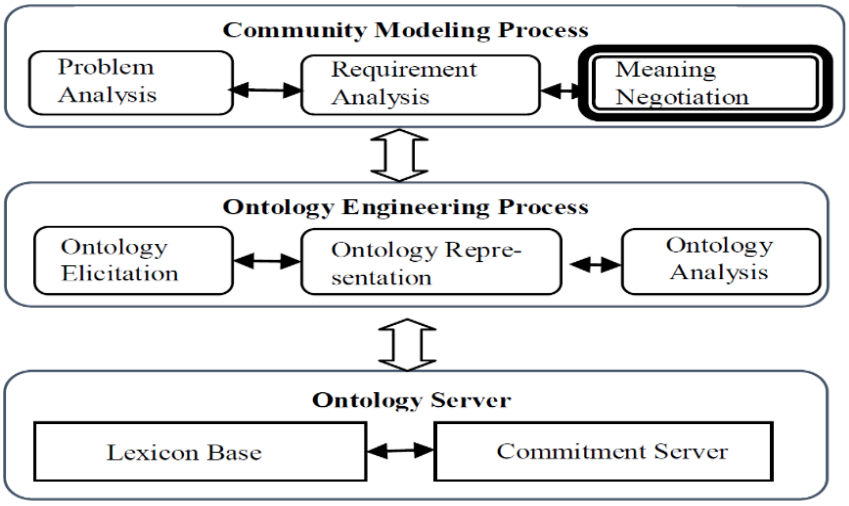

Fig. 1: The DOGMA Framework.

Patterns for the Pragmatic Web: The approach [2] used pragmatic patterns in the meaning process to place ontologies in context. It presented a scenario of negotiation between a seller of cat mats (Matmaker) and an association of the cat lovers (CLAW) in Figure 2.

First, Matmaker sends an initial request (object for sale where the beneficiary is a cat of one meter maximum) to query CLAW; the latter will answer with an empty result. Matmaker will try to generalize the query (object for sale where the beneficiary is a cat) and send it to CLAW; this time Matmaker will have an answer (object for sale where the beneficiary is a small-cat), but it has not yet reached its original objective. To achieve its original goal, it makes a call to the domain ontology in the Semantic Web and uses a dictionary.

The common pragmatic pattern improves the meaning negotiation between the community participants in a context. It reduces the ambiguity of the data that existed on the Semantic Web where it makes the information more relevant and relative to the users need.

The use of ontology for environments like the Semantic Web is difficult. However, it becomes very difficult to find a good granularity of context at the pragmatic level with domain ontology.

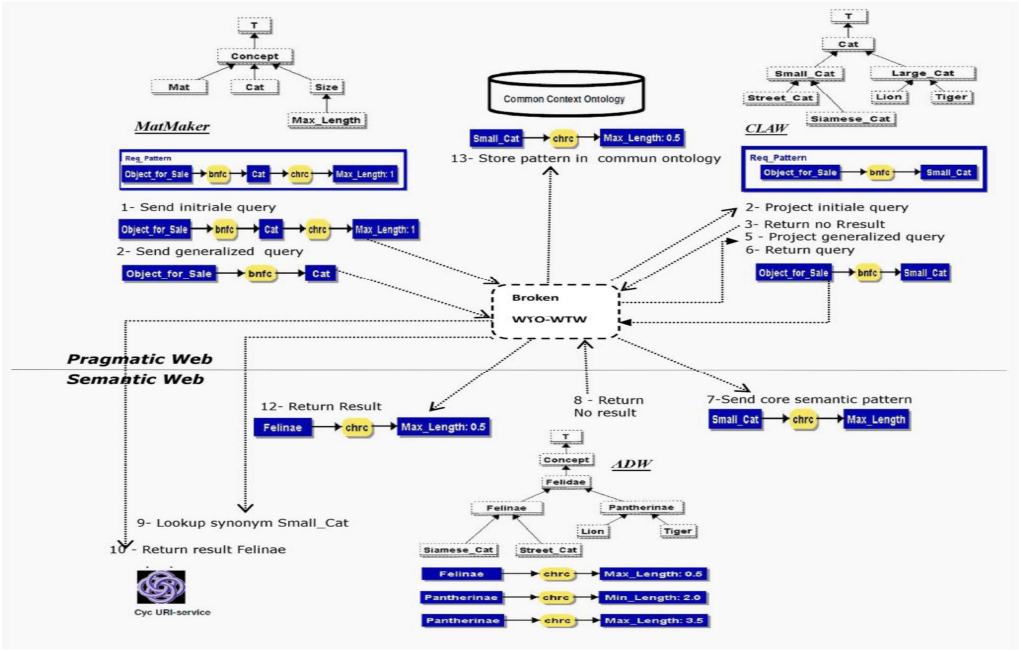

Fig. 1: Example of the meaning negotiation.

Argument basis

Ontology negotiation Goals, requirements, and implementation: the authors in [10] implemented 3 protocols for ontology negotiation in the internet news domain of the Anemone system. The systems put into practice normal communication, ontology alignment and a transition between these ontologies. The first simple protocol looks for the most specific super concept in sets of received concepts. In the second protocol, the Agents seek the most specific concept in the communication vocabulary related to the super concept source. The last protocol allows agents to delete redundancy in the communication vocabulary and sends a message to the receiver indicating removed concepts.
The evaluation of the three protocols was based on four criteria in Table 1: soundness (if there exists a concept source who is a super concept of the concept target), lossless (if there exists a concept source who is most specific in the set of super concepts of the concept target), laziness (Agents teach concepts to each other), construction of minimal CV. These three protocols will become complex when several agents interact.

Table 1. Comparative table.

	Sound	**Lossless**	**Lazy**	**Minimal CV**
Protocol 1	Yes	Yes	No	No
Protocol 2	Yes	Yes	Yes	No
Protocol 3	Yes	Yes	Yes	Yes

A strategy for automated meaning negotiation in distributed information retrieval: The authors in [11] have developed a formal framework that provides negotiation strategies to compare the whole contexts of two background domain theories by calculating the relationships between concepts, instance, properties, and constraints on properties.
The divergences Semantics are defined by the Calculation of the similarity of concepts in their context. Then measure the semantic distance, and calculate the global semantic distance between contexts. After calculating the divergence, they define and choose the best hypotheses of equivalence between the concepts, by using propositional substitutions (define) and Presuppositions (choose). An agreement can be reached if no orphans are left or some orphans are still present, but SD is lower than the agreed threshold. When the orphans (concepts, properties or propositions expressing relations of they have no analogy) still present a revision of some propositional substitutions is applied. The process becomes very complex when the domain theories of each part are very voluminous. It can be very long if the SD is still highly evolved, the orphans still existed and the parties have not exhausted their arguments.
Integrating Ontology Negotiation and Agent Communication: The paper [12] presented an integration of ontological negotiation in multi-agent systems with the use of the notion of translation between the ontologies and the algorithms to calculate these translations; It guarantees significant communication. Agents can exchange terminological information in different private vocabularies. Two cases are possible when agents want to be informed (**Tell**) on an atomic formula of each other:

1. No loss of information: Agent ***j*** uses an update function to include new factual information in the Abox.
2. Loss of information: Agent ***j*** must ask for details about the message by a ***ReqSpec***. Agents ***i*** add a new concept to the vocabulary by ***AddConcept*** action. The agent j looks for concept translation in his ontology by the use of the ***TransCard*** function.

For successful communication, agents exchange factual and terminological knowledge in an individual field. They define the approximate translation of an atomic concept ***C*** as a translation with the most

specific super-concept of ***C***. The translation with a negative atomic concept is a non-significant translation.

3.2. Logical Context Model

The context is defined by facts, predictions or roles; the aim of this model is to form an inference or deductive system, from which a fact is deduced from another fact.

Argument basis

Logical Systems towards Protocols for Web-based meaning negotiation: Authors in [13] used protocols which are based on a logical system, allowing agents to interoperate on Web. When the agents want to inter-operate each one of them take into consideration the logical system of the other to agree. The logical system has three essential components that can inferences on Web.

- If two agents have different deduction systems. These systems will not axiomatize the consequence relation in the same way.
- If agents use different signatures, mapping between different institutions is possible to link between models.
- If the agents use different proof calculus, the consequence relations remain invariant for different proof calculations, so the proof calculations have little effect on the inferences.

The logical system is one basis of the meaning negotiation protocols on the Web, and the mappings between the logical systems are the key to developing these protocols. This approach did not treat the context and pragmatic considerations effects in meaning negotiation.

Meaning Negotiation as Inference: The paper [14] presented a general model of the MN multi-agent. The agents discuss a viewpoint between them to agree on a common angle. The knowledge of agents is represented by two sets, one fixed (stub) and one flexible (flex) which can change to a more descriptive or specific state. The agent exerts a weakening (W) action (a more descriptive), a changing theoretical(C) action (specific state) to change its flexible set. The stubborn(S) action is exercised when the fixed knowledge and the flexible knowledge of agents are equal. Five situations of disagreement are defined between the proposition, the fixed and flexible knowledge of the agent: Call-away, Absolute, disagreement, Essence, disagreement, Compatibility, Relative disagreement.

This approach presented an adequate and coherent deductive system allowing meaning negotiation between agents. This system infers a result in the event that an agreement is reached between the agents. The negotiation process for multi-stakeholder scenarios is very complex, while the approach uses a deduction system that evolved complexity.

3.3. Cognitive Model

Argument basis

Simulating meaning negotiation using observational language games: authors in [15] verified that agents can develop an emerging and shared lexicon by engaging in language games while using the conceptual memory model based on the self-organization map SOM. It implements observation games in a simulated agent population for modeling the process of language acquisition.

A vector that contains the topic characteristic is sent to the agent who will search for the words that correspond to the topic in the neighborhood of BMU (Best Matching Unit). Where no word is found, the agent will pronounce a new word and associate it with the BMU.

The agents can develop a shared lexicon to designate the objects they perceive. This approach did not deal with the case of using multiple SOM for each domain. In this case, a concept will become more

complex. For example, the concept "apple" has properties in different fields, "green" in color, "round" in the shape field, and "delicious" in taste.

3.4. Hybrid Model

Auction

Meaning Negotiation based on merged individual Context Ontology and Part of Semantic Web Ontology: authors in [3] implemented the conceptual model of meaning negotiation [2] based on the presentation of the model multi-agent [14]. Figure 3 illustrates the implementation of [14].

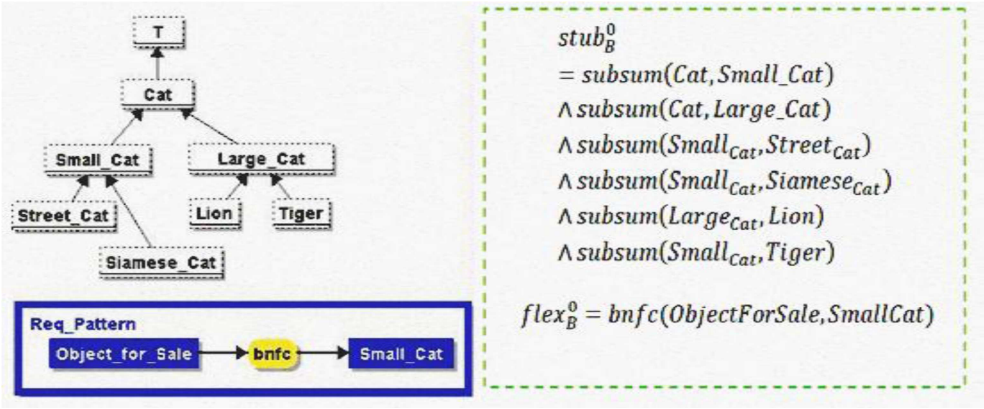

Fig. 3. Example of implementation.

After implementation, they merge in Figure 4 part of the domain ontology and individual context ontology into the Pragmatic Web. The number of steps in [2] is decreased with the merging; in the seventh step of [2] the WYO-WTW service sends the semantic query to the ontology (ADW) in the Semantic Web. With merging, the eighth step will answer this time with a non-empty result, because the Small-Cat concept can find in the ontology merging result. After merging, they Re-implement the meaning negotiation process.

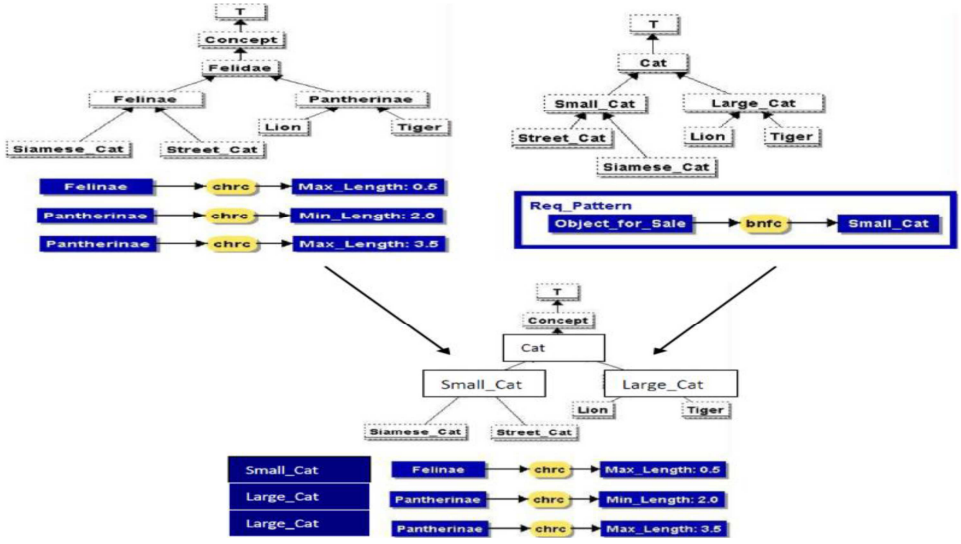

Fig. 4. Example of ontologies merging process.

This approach improves meaning negotiation. It reduced the steps number of [2] from 13 to 9 steps. It optimizes the meaning negotiation process and improves its performance. His contextual model is hybridization between the logical model of [14] and the ontological model of [2].
The merging ontology is a complex process because it is very difficult to find a matching between two ontologies, especially where the ontologies are large. The paper [3] presented a case of study for a single ontology to improve the process [2]; This cannot be validated by single domain ontology.

3.5. Synthesis

After studying the different approaches of the meaning negotiation in the pragmatic web, a comparative table has been produced. Table 2 shows a comparison of approaches using five criteria (field, objective, model of context, the form of negotiation, technical and algorithm).
The table shows two classes of contextual representation either logic or ontological. Note that the ontological representation is more widely used than the logic one that will allow us to use the ontological representation to define our own way. The form of negotiation Argument basis is compatible with the logical contextual model.

Table 2. Comparative table of the stat of the art approaches.

Approaches	Field	Objective	Model of context	The form of negotiation	The Form of negotiation
Farrugia, 2002	Community	Interoperability between agents in the web.	Logic	Argument basis	Logical system.
Magnini et al., 2002	Tourism	Semantic interoperability between ontologies.	Ontology	-	The matrix of matching, WordNet.
De Moor, 2005a	Commercial	Places the ontology in a context.	Ontology	Auction	Web service, Pragmatic Pat-tern.
De Moor, 2005b	Community	Resolve communication ambiguities	Ontology	Auction	Lexicon based, server commitment.
Ermolayev et al., 2005	Book and paper publication	Provides meaning negotiation strategies in a distributed system.	Ontology	Argument basis	Background domain theory, Distributed System, Similarity measure.
Lindh-Knuutila et al. ,2006	Community	Developed an emergent and shared lexicon using the SOM.	The self-organization map (SOM)	Auction	SOM, Observation game.
Van Diggelen et al., 2007	Internet-news	Combined several techniques with the normal communication protocols.	Ontology	Argument basis	Description Logic. Common vocabulary.
Burato et al., 2011	The Car Field	Formalize the negotiation process with an adequate deduction system	Logic	Argument basis	A model EGGS/YOLK, The multi-agents system.

Souza et al., 2015	Community	Integrates negotiation ontology into a communication multi-agent.	Ontology	Argument basis	Algorithms to calculate the translation, SMA.
Keskes and Rahmoun, 2017	Commercial	Merge two ontology (domain and contextual ontology) to improve process of [2].	Hybridization (logic and ontology)	Auction	Web service, Pragmatic Pattern, flexible and stubborn set

The approach [2] is the basic model of the meaning negotiation process. Authors in [3] used the basic model of meaning negotiation but with an improvement while merging context ontology and semantic ontology into a single domain. The approaches are sorted by year from oldest to newest in Table 2.

4. Our Work

The meaning negotiation process in the web is the automatic version of human negotiation. The agent simulates human behavior and exchanges the knowledge in order to make a decision intelligently. This concept is most cited in the pragmatic web.

The meaning negotiation in the pragmatic web represents a new domain for the researchers. Approaches proposed in the meaning negotiation evolve the pragmatic of the web, resolve the communication ambiguities and decrease the ambiguity of semantic data. In our future work, this paper will choose this axis to reduce the existing problem in this domain.

Our work has the idea to extend the schema presented in [3] by the use of five ontologies in different domains. This generalizes the idea in [3] and makes it valid for more domain. The idea is to merge the contextual ontology (where the meaning negotiation takes place) with the domain ontology using the basic model of the pragmatic web of [2]. For this, a simple merging ontology is presented to improve the meaning process.

The merging method uses two similarities, the terminological and semantic similarity between concepts. The terminological similarity compares the string using cosine similarity. The semantic similarity uses the dictionary Power-Thesaurus to link the concepts. For the relevance of concept synonyms, each synonym can be rated by the expert's votes. The Power Thesaurus dictionary selects synonyms for concepts in contextual ontology most rated by experts. Users can add new concept synonyms in the dictionary. This will improve cooperation between experts and return the most relevant meaning, which will influence the negotiation process positively.

Different tools and frameworks used for implementation. For a multi-agent system, the Jade framework is called to simplify the implementation. The meaning negotiation process of [2; 3] are implemented With the Java J2EE. To model the context in owl format (ontology), the protégé 2000 tools is used. For the interaction between the Java and ontology, Jena framework will be integrated.

5. Result and Discussion

The paper of [3] compared the result obtained according to the number of operations in the original meaning process. It will be more significant to compare between the process according to total run time. Authors compare the total time of process on five domain datasets to be more precise on the influence of merging in the meaning negotiation process.

Table 3. The result tables.

Domain	**Step number Without merging ontologies**	**Run time Process Without merging ontologies**	**Step number with merging ontologies**	**Run time Process Without merging ontologies**

University	53	10 Second	37	4 second
Finance	91	18 Second	81	20 Second
Tourism	39	12 Second	27	5 Second
Biology	24	24 second	16	15 Second
Music	25	5 Second	21	1 Second

The table 4 represents the result obtained according to steps operation and run time. The first column presents the domain selected. The next two columns contain the step operation and run time of meaning negotiation process of [2] in several domains. On the other side, find the steps and time obtained in the meaning negotiation process using merging ontologies. Generally, the merging ontologies improve the meaning negotiation process decreasing steps and run time. Time criterion is important for comparing the meaning negotiation process. The time decrease using merging ontologies in the process because of the use of the dictionary in the merging. This will allow the process to delete the step of search in the dictionary that takes the biggest time in the process. The run time of the process with ontologies merging notion can be longer that of the original process according to the volume of ontology merged.

6. Conclusion

Faced with this profusion and this information overload, the user paints to identify the relevant information that best suits his needs. In this context, meaning negotiation in the pragmatic web has been developed to facilitate access to relevant information. However, suc0cessful approaches to creating the Semantic Web are under pragmatics, but the problems of overload, the ambiguity of information remain. To find answers to these problems, these papers have exploited the field of a pragmatic web specifically meaning negotiation.

The paper studies state-of-the-art research relating to the meaning negotiation in the Pragmatic Web. It classifies them in four essential classes according to their context representation. This paper compares between approaches according to different criteria: the objective, domain, contextual model, the form of negotiation auction or based on argument and the different technique and used algorithms.

Our work is based on the meaning negotiation model of [2] and the model of [3] which uses merging to optimize the meaning negotiation process. The method [3] must be generalized for any domain where a benchmark of 30 ontologies in different fields is presented. This will prove the validity of merging ontologies in the meaning negotiation process according to run time.

The paper briefly introduces our idea where the schema of meaning negotiation [3] will be extended in different domains. It demonstrates the influence of merging ontologies in the meaning negotiation process by presenting comparative studies based on the run time criteria. The meaning negotiation process based on merging ontologies reduces the run time of the original process.

References

[1] P. Dimaio. The Missing Pragmatic Link in the Semantic Web. Business Intelligence Advisory Service, 2008, vol. 8, no 7.

[2] DE MOOR, Aldo. Patterns for the pragmatic web. In: *International Conference on Conceptual Structures*. Springer, Berlin, Heidelberg, 2005. p. 1-18.

[3] KESKES, Nabil et RAHMOUN, Abdellatif. Meaning negotiation based on merged individual context ontology and part of semantic web ontology. *IJICT*, 2017, vol. 11, no 3, p. 352-368.

[4] PASCHKE, A. Pragmatic Web 4.0. Towards an Active and Interactive Semantic Media Web, W3C Aspect of Semantic Technologies. 2013. 2015.

[5] SINGH, Munindar P. The pragmatic web. *IEEE Internet Computing*, 2002, no 3, p. 4-5.

[6] MUSTAPHA, SMFD Syed. CoP sensing framework on web-based environment. In : *Web-based Support Systems*. Springer, London, 2010. p. 333-357.

[7] DEY, Anind K., ABOWD, Gregory D., et SALBER, Daniel. A conceptual framework and a toolkit for supporting the rapid prototyping of context-aware applications. *Human–Computer Interaction*, 2001, vol. 16, no 2-4, p. 97-166.

[8] MAGNINI, Bernardo, SERAFINI, Luciano, et SPERANZA, Manuela. Using NLP Techniques for Meaning Negotiation. In: *Proceedings of VIII Convegno AI* IA, Siena, Italy*. 2002. p. 11-13.

[9] DE MOOR, Aldo. Ontology-guided meaning negotiation in communities of practice. In: Proc. of the Workshop on the Design for Large-Scale Digital Communities at the 2nd International Conference on Communities and Technologies (C&T 2005), Milano, Italy. 2005.

[10] VAN DIGGELEN, Jurriaan, BEUN, Robbert-Jan, DIGNUM, F. P. M., *et al.* Ontology negotiation: goals, requirements and implementation. *International Journal of Agent-Oriented Software Engineering*, 2007, vol. 1, no 1, p. 63-90.

[11] ERMOLAYEV, Vadim, KEBERLE, Natalya, MATZKE, Wolf-Ekkehard, *et al.* A strategy for automated meaning negotiation in distributed information retrieval. In: *International Semantic Web Conference*. Springer, Berlin, Heidelberg, 2005. p. 201-215.

[12] SOUZA, Marlo, MOREIRA, Alvaro, VIEIRA, Renata, *et al.* Integrating Ontology Negotiation and Agent Communication. In: *International Experiences and Directions Workshop on OWL*. Springer, Cham, 2015. p. 56-68.

[13] FARRUGIA, James. Logical Systems: Towards protocols for Web-based meaning negotiation. In: *Proc. of AAAI 2002 Workshop on Meaning Negotiation*. 2002. p. 56-59.

[14] BURATO, Elisa, CRISTANI, Matteo, et VIGANO, Luca. Meaning negotiation as inference. *arXiv preprint arXiv:1101.4356*, 2011.

[15] LINDH-KNUUTILA, Tiina, HONKELA, Timo, et LAGUS, Krista. Simulating meaning negotiation using observational language games. In: *International Workshop on Emergence and Evolution of Linguistic Communication*. Springer, Berlin, Heidelberg, 2006. p. 168-179.