# Knowledge Level Support for Web-Agents to Engage in Content Negotiation[1]

Yousouf Taghzouti

The World Wide Web, which we commonly call the Web was proposed as an information management system [1]. It provides universal access to a vast set of interconnected resources. A resource is anything worth referencing. Each resource can have different representations that capture its state and can vary along several dimensions: media type such as HTML or PDF; or language like English and Arabic. *content negotiation* is the mechanism used to select an appropriate representation from among those available.

The Web is heavily used by human and software agents achieving their goals by browsing and acting on Web resources [4]. For instance, search engines that employ crawlers to navigate and index web content are a notable well known case [3].

The Semantic Web aims at extending the Web with semantics i.e. providing meaning and structure to web content. In *The Semantic Web* article [2], Tim Berners-Lee and colleagues presented a scenario where agents interact with each other to achieve some goals. For example, agents may need to extract knowledge from some servers. If multiple representations are present, agents may need to engage in content negotiation, which can prove difficult because agents do not always have a priori knowledge of the content negotiation properties used by a web server.

We propose our contribution towards enabling Web-agents to engage in content negotiation through knowledge level support and subsequently facilitate the interaction and increase the interoperability of heterogeneous systems. Our approach consists of two steps. First, we propose *CNCO*,[2] our ontology to provide web agents with a knowledge layer to describe the content negotiation characteristics. Second, we use a Multi-Agent Oriented Programming platform to model and handle the resource discovering, agent reasoning and acting when engaging in content negotiation after consuming the negotiable resource descriptions obtained in the previous step.

When developing the *CNCO* ontology and the supporting vocabularies, we relied on the paper [6]. that provides a state-of-the-art overview of content negotiation and describes its characteristics in great detail.

Figure 1 depicts a simplified overview of *CNCO*. In addition, we define four vocabularies: content negotiation dimensions, content negotiation styles, content negotiation protocols and content negotiation constraint conveyance means. The first three vocabularies provide instances of the classes `cnco:CnDimension`, `cnco:CnStyle` and `cnco:CnProtocol`, which can be used out of the box when describing negotiable resources. The latter provides concepts and properties for defining `cnco:CnCcMeans`.

Listing 1 shows an example of how to describe a negotiable resource using the *CNCO* ontology together with the four supporting vocabularies. In the example we state that the resource HMAS ontology identified by https://purl.org/hmas/ is a `cnco:NegotiableResource` and therefore its representations are negotiable. The content negotiation dimension, style and protocol are media type, proactive and HTTP respectively. The header `accept` should be used to convey the constraints.

[1] This position statement is based on a chapter of my PhD thesis entitled: *Semantic Content Negotiation: A fine-grained and relaxed approach using Semantic Web technologies* [5].

[2] CNCO: https://w3id.org/cnco

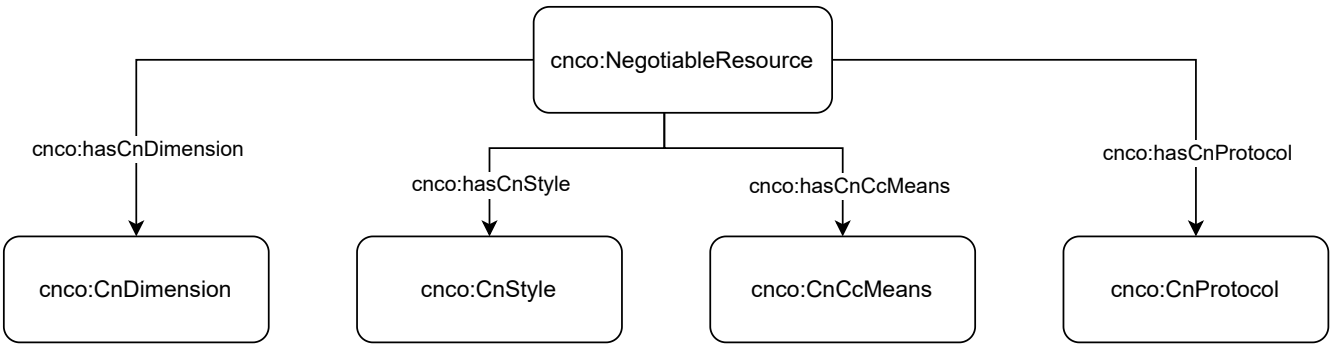


Figure 1: Overview of the content negotiation ontology

Listing 1: An example of a negotiable resource described using the *CNCO* ontology

```
...
<https://purl.org/hmas/> a cnco:NegotiableResource;
    rdfs:label "Hypermedia MAS Core Ontology";
    rdfs:comment "An ontology to describe Hypermedia Multi-Agent Systems,
       interactions, and organizations.";
    cnco:hasCnStyle cnstyle:proactive;
    cnco:hasCnDimension cndimension:mediatype;
    cnco:hasProtocol cnprotocol:http;
    cnco:hasCnCcMeans [ a cnccmeans:HeaderBased;
        cnccmeans:usesHeader "accept". ].
```

# References


[1] Berners-Lee, T.: Information Management: A Proposal. Tech. rep., CERN (Mar 1989), https://www.w3.org/History/1989/proposal.html

[2] Berners-Lee, T., Hendler, J., Lassila, O.: The Semantic Web. Scientific American **284**(5), 34–43 (May 2001), https://www.scientificamerican.com/article/the-semantic-web/

[3] Brin, S., Page, L.: The anatomy of a large-scale hypertextual web search engine. Computer networks and ISDN systems **30**(1-7), 107–117 (1998), https://www.sciencedirect.com/science/article/pii/S016975529800110X

[4] Ciortea, A., Mayer, S., Gandon, F., Boissier, O., Ricci, A., Zimmermann, A.: A Decade in Hindsight: The Missing Bridge Between Multi-Agent Systems and the World Wide Web. In: Proceedings of the 18th International Conference on Autonomous Agents and MultiAgent Systems, AAMAS '19, Montreal, QC, Canada, May 13-17, 2019. pp. 1659–1663. International Foundation for Autonomous Agents and Multiagent Systems (2019), http://dl.acm.org/citation.cfm?id=3331893

[5] Taghzouti, Y.: Semantic Content Negotiation: A Fine-grained and Relaxed Approach Using Semantic Web Technologies. Ph.D. thesis, École des Mines de Saint-Étienne (2024), https://theses.fr/s279089

[6] Taghzouti, Y., Zimmermann, A., Lefrançois, M.: Content Negotiation on the Web: State of the Art. Tech. Rep. abs/2204.10097, CoRR (Apr 21 2022), https://arxiv.org/abs/2204.10097