# ABCT: The Activity based Contextual Tagging Ontology

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Abstract: A large amount of applications now includes tagging mechanisms that have proven efficiency to organize, navigate through, retrieve, and discover online resources. However, despite the valuable research work done to improve these solutions, the literature shows that a further step has to be done in order to better consider the contexts in which tagging actions occur. In this paper, we define a list of elements constituting a tagging context that should be considered in order to better give access to the knowledge shared through users' taggings. We propose an ontological model named ABCT (Activity Based Contextual Tagging) for describing these contexts. ABCT takes benefits from the many research in tagging ontologies and that are synthetized in MUTO (Modular Unified Tagging Ontology). ABCT marries MUTO and PROV (Provenance) concepts to facilitate the description of tags and tagging contexts, essentially through to the notions of *Tagging* and *Activity*.

## 1 INTRODUCTION

In the past decade, tagging systems have become an essential part of a wide range of applications (knowledge-management, social media, repositories, online stores, etc.). One of the reasons of this infatuation is that, in our world where the number and variety of resources (information, materials, software…) are constantly and rapidly growing, researchers have shown that tagging systems can really help in organizing, navigating through, and retrieving them (Ames and Naaman, 2007; Oleksik et al., 2009). Moreover, tagging systems have been successfully used to let end-users (by opposition to resource developers and/or domain experts) themselves organize this plethora. Researchers have shown that this mechanism is really interesting since tags reflect their creator's experience, and tagging a resource is sharing knowledge about it (Saab, 2010). In tagging systems, end-users' knowledge shared through tags is expected to help other users in better finding, understanding and selecting resources according to their own specific needs (Singer et al., 2013).

Many research work has been realized to enhance tagging systems. In a previous paper (Bourguin and Lewandowski, 2017), we proposed a litterature review that explores studies and solutions dedicated to folksonomies (Knerr, 2006; Cernea et al., 2008; Saab, 2010) and ontologies (Kotis and Vouros, 2006; Dong et al., 2015; Garcia-Silva et al., 2014; Zhitomirsky et al., 2017), while trying to better understand the essence of tags. A tag carries semantics that provides meaning about a resource. However, information is only useful to the extent that other users make sense of the content in the same way (Golder and Huberman, 2006). A tag reflects it's creator's knowledge, but knowledge can be fully understood only while considering the context it comes from (Ning and O'Sullivan, 2012). This explains why most tagging solutions have proposed to enhance tags by linking them to information related to their creation context.

Following this trend, we also proposed the basis of a new tagging framework (Bourguin and Lewandowski, 2017). However, our analysis leaded us to consider the notion of context in a wider way than in the previous solutions by linking tags not only to their creator (or creator's intention), but to their whole creator's activity, thus potentially providing much more contextual information.

In this paper, we consolidate our approach by defining the Activity Based Contextual Tagging (ABCT) ontology. ABCT is designed to take benefits from most of the previous propositions in *Tagging* ontologies and that were synthesized in the Modular Unified Tagging Ontology (MUTO, Lohmann et al., 2011). ABCT extends MUTO by merging its



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concepts with the W3C PROV ontology (W3C, 2013) which's purpose is to describe entities and provenance information synthesized in the concept of *Activity*. To our knowledge, ABCT is the first tagging ontology explicitely anchoring tags in their creator's activity, i.e. where they were created and used, and thus enabling to capture more information about the context in which they really make sense.

In the first part of the paper, we define elements that should be considered while capturing tagging contexts, because they bring information that allows to assess them and to understand a user's particular viewpoints. The second part of the paper presents ABCT, the ontological model we propose to describe tagging in context, which can be viewed as a dedicated marrying of the MUTO and PROV data models. Finally, we illustrate ABCT's main benefits with an example showing how this framework can help to capture contextual users' taggings in a global multi-viewpoint ontology.

# 2 TAGGING CONTEXT

While studying strengths and weaknesses of folksonomies, many researches have shown that tagging context is crucial for better understanding tags (Ning and O'Sullivan, 2012). Qassimi et al. (2016) underline that tags synonymy (multiple tags holding the same meaning) is not transitive but fundamentally context dependent. They also recall that polysemy in one of the central issues in the psychology of word meaning, and that a polysemous word cannot be fully understood if considered out of context.

In fact, many tagging solutions propose to link tags to some entities related to their creation context. In most cases, this information is directly related to the creator of the tag. For example, Newman's TAGS (Newman, 2005) proposed to link tags to their tagger through the tagging concept, and NiceTag (Monnin et al., 2010) proposed to represent the intention of the tag's creator.

Most of these initial propositions were synthesized in MUTO (Lohmann et al., 2011), a tagging ontology we will further describe in the next part of this paper. However, we argue that this information, even if necessary, is not sufficient to fully understand tags and tagged resources. Our assumption is that we need to enlarge the notion of context. We propose here the list of elements that we consider as the context that can help in understanding a tagging action.

## 2.1 Contextual Elements

The following elements are those usually already represented in existing tagging systems:

- ***The resource***. Obviously, knowing which resource is concerned by a tag helps in better understanding it. For example, the label 'pink' can have several meanings. Knowing that this label has been associated with a photo of the famous singer, the ambiguity is weakened.
- ***The other tags on the same resource***. The tag 'beach' usually triggers some deep blue sea and palm trees images in the mind. If we see the other tags 'Battle of Dunkirk' and 'Second World War' on the same entity, it gives us more knowledge about this 'beach' which does not refer to some paradisiac island, but to the historic place where tragic events occurred.
- ***The tag's creator***. The 'Java' tag may refer to a town, a France originated dance, or even a chicken. Knowing that a well-known software programmer created this tag lets understand that the targeted resource has more probably links with the famous programming language.

The following elements are related to the activity in which tagging occurred. Even if some tagging systems provide some clues about the taggers' activity, like the localization of the tagging action (Qassimi et al., 2016), they do not consider activity and its related elements in the large as we do here:

- ***The activity in which the tagging occurs***. Finding the tag 'Head' on a Christmas ball may be somehow confusing. As we will show in our example described in part 4, discovering that this tag has been created in an activity dedicated to the creation of a decorative unicorn for a child bedroom levers the ambiguity.
- ***The other resources involved in the activity***. A resource is rarely used alone. Knowing which other resources are associated with a particular one can help to assess this latter and the tag(s) put on it. For example, a tag 'model' describing an entity in an activity that involves a camera and spotlights will not trigger the same meaning than another entity associated with a programming language and a database server.
- ***The tags on the other resources***. Let's consider once again our Christmas ball tagged with 'Head'. Even without considering the activity name, this tag is more easily understood if discovered with other specific resources tagged 'horn', 'body', 'legs' and 'rainbow'.

- ***The tags on the activity*** can be used to inform about the activity type and provide useful contextual information. In our previous work (Bourguin and Lewandowski, 2015, 2017), we considered MMORPG players (Massive Multiplayer Online Role Playing Game) sharing their character's build. Each build (an assemblage of game resources) is relevant for a specific activity type, and a each type is usually described by tags like 'tanking', 'healing', 'dps' (damage dealing). Players sometimes tag resources as 'OP' (Over Powered). Such information is really impacting for other players, but 'OP' does not give much information if not considered in the context of an activity type: indeed, a resource can be 'OP' for 'tanking', but highly inadvisable for a 'dps' activity.
- ***The tags on the creator*** can inform about his/her profile, his/her role(s) in the activity, and this knowledge could give more sense to the considered tag. For example, if a user is tagged 'Web designer', we understand that the tag 'Head' s/he put on a particular resource stands for its position on the web site, and not for the upper part of the human body.
- ***The other actors in the activity***. Let's consider the tag 'to read' put on a particular resource. If only one user is involved in a private activity, we may deduce that s/he created this tag for her/himself, as a reminder. At the opposite, if 'to read' is created by a teacher in an activity involving several students, we understand that this tag stands for a reading recommendation.
- ***The other activities a tagger is involved in*** can help in assessing a tag. For example, knowing the many projects in which a programmer is involved in, and her/his contributions, offers an overview of her/his skills and experience, which may be concentrated around the Java language: this can lead to better understand why s/he tagged as 'Best' a GUI Java Framework, while C++ specialists would certainly have tagged 'Best" another one. Indeed, from its surrounding activities, we implicitly understand here 'Best' as 'Best for Java' instead of 'Best of all'.

## 2.2 Capturing and Sharing Viewpoints

As described in the previous part, we think that a tagging system would gain benefits from linking tags to numerous contextual elements. Each entity is linked to many other entities (e.g. all the tags associated by all the system's users with a particular resource in a folksonomic fashion), but some links are stronger since they represent a particular context that can help to better understand the act of tagging, and then the associated meaning. Focusing on these particular stronger relations between entities in a particular context offers what we call a viewpoint.

The viewpoint notion is more and more identified as essential by researchers interested in sense making. Indeed, providing meaning about things is always sharing a viewpoint. As recalled by Bénél and Lejeune (2009), meaning of things is always plural and trying to provide a unique definition is thus problematic in essence. Zhitomirsky□Geffet et al. (2017) underline that even ontologies defined by domain experts and expected to provide a unique and agreed shared definition about domains entities, can only be considered as experts' viewpoints. They also underline that different experts rarely share the same viewpoint, and even more that an expert's viewpoint rarely matches the ontology's users one. This certainly explains why a large part of today's research in ontologies is dedicated to ontologies alignment, a discipline trying to create bridges between different ontologies representing the same domain, but defined by different experts, thus providing different viewpoints. This also certainly explains why a new trend has emerged in this research area while introducing the need for multi-viewpoints ontologies (Kotis and Vouros, 2006) (Pinto et al., 2009) (Zhitomirsky et al., 2017). Indeed, as reported by Zhou and Bénel (2008), a system for helping sense making should let users distinguish and compare viewpoints: once interpretation conflicts permit to distinguish different viewpoints, people are then able to choose and/or create their own.

As a result, we think that a tagging system has to provide means to retrieve the viewpoint a set of entities are participating in, to focus on a particular one for better understanding, and to browse and compare them. This approach is really close to the one developed in the frame of Hypertopic (Cahier and Zacklad, 2006) and its associated technologies (Cahier et al., 2013). The Hypertopic framework lets users define a *Corpus* in which *Items* can be associated with a *Topic* (tag) in the context of a *Viewpoint* (a set of *Topics* characterizing *Items*). The main difference between Hypertopic and our approach relies in our framework definition since we choose to use the *Activity* (and constituting elements) as a central concept to provide context for *Tagging*. The main motivation is to more directly consider that tagging is an action that is performed by an actor in the context of an activity, i.e. a motivated aggregate of actors, resources, etc. In our approach, *Activity* and *Tagging* are used together to capture and share viewpoint(s). The resulting framework has been defined as an ontology we called ABCT.

# 3 ABCT ONTOLOGY

ABCT (Activity Based Contextual Tagging) is an evolution of our previous work (Bourguin and Lewandowski, 2015, 2017). In this previous approach, the main idea was to let users describe their viewpoints into Personal Ontologies (PO). Indeed, each PO was itself a separate ontology in which tags were not instances of a tagging concept, but were themselves concepts (i.e. instances of *owl:Class*). Users were able to describe their own understanding of the world in their own ontologies, while directly taking benefits from ontological mechanisms like consistency checking and inference. Our application framework was designed to let end-users unfamiliar with semantic technologies create their own owl ontologies. Experiments have shown interesting results, letting users from different domains (scrapbooking, MMORPG, e-learning) share their experience. However, this approach showed limitations too mainly due to the fact that, each viewpoint being a PO, the application generated numerous separate ontologies.

In ABCT, we aim at providing a single global ontology containing all the user's different viewpoints, thus facilitating the global querying that will serve our many purposes like exploration, viewpoints comparison, recommendation and so on.

The two main concepts driving this research are *Tagging* and *Activity*. Instead of creating a new model from scratch, we decided to take benefits from recognized research results in modelling these two concepts. Representing *Tagging* is the purpose of MUTO, and *Activity* description is the motivation of W3C's PROV. ABCT stands as the merging of MUTO and PROV in a new ontology designed to support our needs.

## 3.1 MUTO

Trying to cope with the limitations of the first folksonomic systems, several tagging ontologies have been developed. Each of these ontologies proposed a variation of the semantic representation of folksonomies and, more precisely, a model for representing a tagging while enhancing the tag concept. As reported by Lohmann et al. (2011), the large number of these tagging ontologies made it difficult for developers to find the best ontology that meets their need. The authors thus proposed the Modular Unified Tagging Ontology (MUTO), a unification of the existing tagging models. MUTO provides a tagging ontology designed to combine the best of the nine most recognized tagging ontologies, and this is why we decided to use it as a foundation in ABCT for representing the *Tagging* concept.

Briefly described, in MUTO, users (single user or group) instances of *sioc:UserAccount*, create some *muto:Tagging.* Each *muto:Tagging* is linked to a *rdfs:Resource* and can contain ordered instances of *muto:Tag*. Each tag is unique (even if multiple tags have the same string as *rdfs:label*) and can be associated with a meaning (a *rdfs:Resource* like a concept in another ontology). More information can be described like tag hierarchy (a *muto:Tag* being subclass of *skos:Concept)*, private tagging, auto tagging, creation and modification dates, etc. The full descriptions of MUTO can be found in (Lohmann et al., 2011).

As we can see, MUTO provides an interesting basis for managing users' tagging (and tags). Some contextual information can be described: mainly the user's account that created the tagging. However, MUTO does not provide entities facilitating the description of the tagging context as we introduced it previously. In our approach, the context for tagging actions is the *Activity*, a concept that doesn't exist in MUTO, but that is central in W3C's PROV.

## 3.2 PROV

The PROV data model is a standard proposed by the World Wide Web Consortium (W3C) to represent the provenance and history of data on the web. The W3C defines provenance as "a record that describes the people, institutions, entities, and activities involved in producing, influencing, or delivering a piece of data or a thing." (W3C, 2013). According to the W3C, capturing and representing the provenance of information can help users to understand it, to decide whether to trust it, or to know how to integrate it

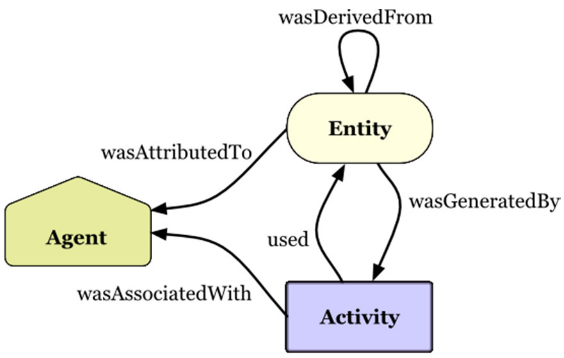


Figure 1: PROV data model core concepts (W3C, 2013).

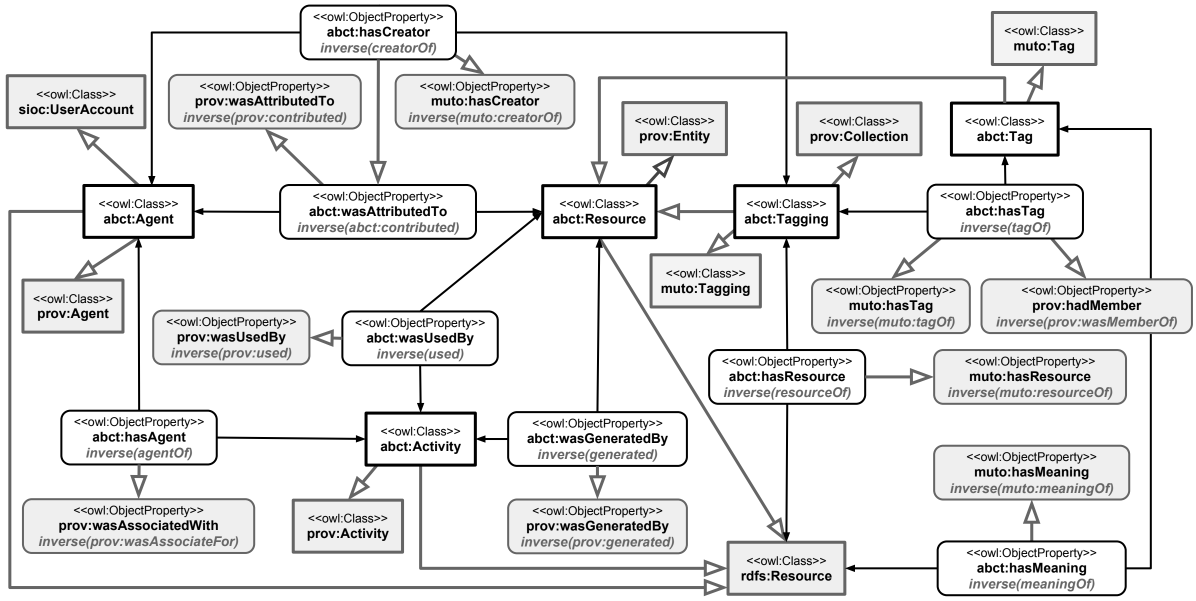


Figure 2: ABCT ontological data model, based on MUTO and PROV.

elsewhere. These considerations clearly correspond to our needs concerning the elements that constitute the context of a tag and that could help in assessing it. Furthermore, the PROV data model has been found usable and useful for end-users (Bachour et al., 2015).

Figure 1 shows the core concepts of the PROV data model, which are described with more details in (W3C, 2013) and (Moreau et al., 2015): *prov:agents* participate in *prov:activities* that can use or produce *prov:entities*. These *entities* describe digital, physical or other things (documents, objects, web sites, etc). Thanks to these three core concepts and their relationships, PROV can model the creation (*prov:wasGeneratedBy*) and the usage (*prov:used*) of resources, the derivation of resources from other resources and the versioning of resources (*prov:wasDerivedFrom*), humans or other things involved in activities (*prov:wasAssociatedWith*), or being responsible for some entity (*prov:wasAttributedTo*). Furthermore, PROV data model offers the means to refer to several other concepts such as time, location, role, and plan. All these concepts can help us to describe the context in which a tagging action occurred.

## 3.3 ABCT

ABCT is designed to ease the instantiation of (MUTO) *Tagging*(s) framed in the context of (PROV) *Activity*(ies). For this purpose, ABCT classes and properties (see Figure 2) inherit from MUTO and/or PROV classes and properties. For example, the *abct:Tagging* class is defined both as a subclass of *muto:Tagging* and *abct:Resource,* which itself is a subclass of *prov:Entity*. Doing so, a tagging can be described as an *abct:Resource* being part of (*abct:wasUsed*) and/or generated by (*abct:wasGeneratedBy*) some *abct:Activity* (a subclass of *prov:Activity*). We can also specify that this tagging has been created (*abct:hasCreator* : sub-property of both *prov:wasAttributedTo* and *muto:hasCreator*) by an *abct:Agent* (subclass of *prov:Agent*, and *sioc:UserAccount* – cf. MUTO) that itself can be an *abct:agentOf* some *abct:Activity*. Inspired by MUTO, an *abct:Tagging* may contain multiple instances of *abct:Tag*; this explains why *abct:Tagging* is also defined as a subclass of *prov:Collection*, and why the *abct:hasTag* object property inherits from *muto:hasTag* and *prov:hadMember*. One can notice that an *abct:Tagging* is targeting (*abct:hasResource*) an *rdfs:Resource*, which is the superclass of all of the previously described entities. As a result, this model enables to (contextually) tag any resource, but also agents and activities. In fact, even taggings and tags could themselves be tagged by agents in the same or other activities, thus providing their viewpoint concerning a tagging or tag: an information that can for example help in creating collaborative features supporting the building of shared viewpoint(s) like in HCOME (Kotis and Vouros, 2006) and Collaborative Protégé (Tudorache et al., 2008).

Instances of this model allow to describe tagging performed by some (types of) agents in some (types

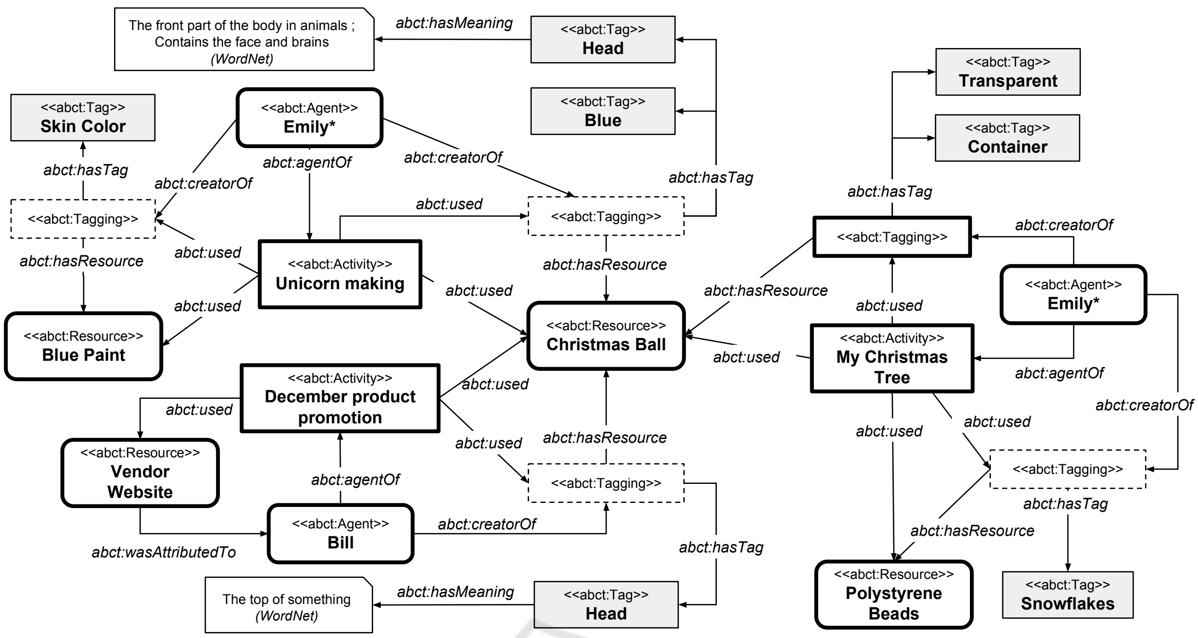


Figure 3: Partial example describing several tagging contexts using ABCT ontological data model.
*(* Emily appears twice in this figure for readability, but the 2 boxes represent the same entity).*

of) activities, and its implementation (we realized with Apache Jena) makes it possible to retrieve specific taggings and their associated contextual information through SPARQL queries.

As it was underlined in the previous paragraphs, MUTO and PROV ontologies both provide means for describing more detailed information like tagging creation and modification date, tags ordering and hierarchy (inherited from SKOS through MUTO), and the possibility to keep track of the evolution of the many entities through PROV (e.g. specifying that a tag or tagging was derived from another one). In other words, creating and specifying ABCT entities and properties allows to describe contextual tagging, but it also enables to provide more detailed information concerning each facet: (MUTO) tagging and (PROV) activity.

## 4 SAMPLE APLICATION

Figure 3 briefly illustrates how the ABCT framework can be used to model three specific viewpoints related to a same resource. It is inspired by our nascent work in applying ABCT in the development of new functionalities for a French company. This company mainly sells decoration supplies (furniture, materials, etc.) in around twenty French stores, and also provides an online shop in which its (decoration) designers and customers can share pictures and explanations about what they produced while using some of the shop's goods in a DIY (Do It Yourself) trend. For reasons of space and conciseness, this example uses information extracted from real articles posted on the website and sample ideas mixed together for quickly showing the problems related to tags' semantics, and the solution proposed by ABCT in providing the needed contextual information.

The example focuses on a simple shop's good presented with a picture: a plastic transparent *Christmas Ball*. One can notice that, in this small example and following a classical folksonomic approach, this resource would be presented with all the tags: *Head*, *Blue*, *Transparent* and *Container*. Such description of a Christmas ball can be somehow intriguing and confusing: how can it be a head, a container (for a brain?), at the same time blue and transparent? This is where the details captured through the ABCT framework can help.

In this example, ABCT enables to know that an *abct:Agent* named *Emily* is involved in an *abct:Activity* named *Unicorn making*, a DIY activity aiming at building a unicorn for decorating a child bedroom and by assembling several materials. In this activity, *Emily* uses the Christmas ball as the unicorn's *Head*, puts some *Blue* paint on it, and other resources that do not appear in the figure 3 for readability. She did not use the *Container* tag in this activity: it appears meaningless in this context. She also put the tag *Skin Color* on the blue paint: blue is not an awaited colour for skin, but it is actually meaningful in the *Unicorn making* activity.

*Emily* performed another activity named *My Christmas tree* where she also used the same *Christmas Ball*, but this time as a *Transparent Container* filled with some *Polystyrene Beads* tagged as *Snowflakes*. As we can see, our same *abct:Agent* adopted a somewhat different viewpoint on the *Christmas Ball* while associating it with different resources and for another purpose.

Finally, the example shows that this Christmas ball is also characterized from a web designer viewpoint, in an activity named *December product promotion*. Bill is in charge of organizing the vendor website and he put the tag *Head* on the *Christmas Ball*, to denote the fact that this article has to be used in the heading of the website. One can notice that both *Emily* and *Bill* used the *Head* tag on the *Christmas Ball*. However, using the *abct:hasMeaning* property, this same label can be associated with different meanings depending on the adopted viewpoint.

This example shortly illustrates some of the many problems that may rise when the tagging contexts are not explicit. It also exemplifies how the contextual elements identified in part 2.1 can be made explicit through the ABCT framework. Querying the populated ontology can help in discovering, browsing and selecting viewpoints, and then assessing and better understanding the many tags as they were thought from their creator's viewpoint.

# 5 CONCLUSIONS

Despite of the large number of solutions using a tagging system to let users share their knowledge about diverse resources, the literature shows that tagging models still miss important information. Most researchers report that tags cannot be fully understood if disconnected from the context in which the corresponding tagging actions occurred. Even if evolving research in tagging ontologies has proposed new models to capture more contextual information, we think that considering a larger notion of context can enhance these models.

In our approach, the context for tagging action is the tagger's activity that frames the many entities participating to a task performance. Inspired by previous research, we listed the main elements that provide contextual information for a better understanding of tags and tagged entities. Our main idea is that each particular activity offers a viewpoint, and exploring a viewpoint gives access to the specific set of elements that provides the context needed to understand each other.

Building on these results, we proposed a new framework founded on the *Tagging* and *Activity* main concepts. Our proposition aims at providing a contextual tagging ontological model that facilitates the building of ontology that captures and allows exploring viewpoints. For this purpose, we proposed the ABCT ontology, a marriage of MUTO – the synthesis of most recognized *Tagging* ontologies – and PROV – W3C's ontology for representing provenance thanks to the notion of *Activity*.

With a small sample application, we underlined the main features and possibilities provided by ABCT for capturing contextual tagging. Due to a lack of space, we did not explore here dimensions concerning specific viewpoints connections and that can be represented by specific links between activities, like the recursive structure that lets define global or sub activities (allowing to represent different viewpoints participating in a global and maybe cooperative activity).

ABCT's implementation is only at its beginning. We already created an OWL representation of ABCT with Protégé, and put it in action in a JEE REST server. Our first applications use Apache Jena for ontology building (capturing viewpoints) and SPARQL for querying (exploring and exploiting viewpoints). These early experiments in supporting knowledge builders and users involved in the different application domains we briefly mentioned in this paper (e-learning, software development, e-store, and gaming) are actually very promising.

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