Managing Contextualized Knowledge with the CKR

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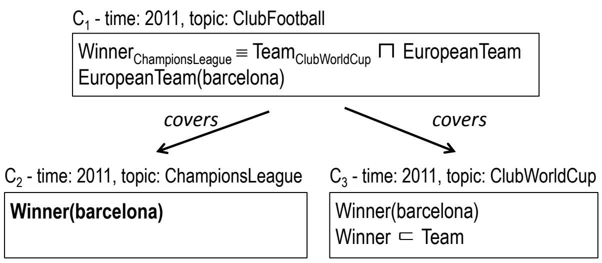
As large amounts of Linked Data are published on the Web, it is becoming apparent that the validity of published knowledge is not absolute, but often depends on time, location, topic, and other contextual attributes. Therefore, an increasingly perceived need for Semantic Web (SW) applications is the representation of the *context* of such knowledge and its formalization for using it in reasoning and querying.

Recognizing this problem, several extensions of RDF and OWL to support contextual qualification of knowledge have been proposed [1, 3, 5, 7]. Among these, we recently presented the Contextualized Knowledge Repository (CKR) [6], a framework with a well-founded semantics based on established AI principia [2, 4] for contextual representation and reasoning.

A distinguishing feature of the CKR is that contextual organization and knowledge propagation among contexts are largely derived from the qualification of knowledge along contextual dimensions: thus, users are not asked to manually express complex bridging axioms to define context relations.

While our previous work has mainly focused on the formal definitions and implementation of the CKR framework, the proposed poster illustrates the practical applicability of CKR features in real-world SW applications. The poster presents a concrete example of CKR use under the point of view of the tasks of *modelling*, *reasoning* over and *querying* contextualized knowledge.

In the poster, a modelling example in the domain of football is used to illustrate the use of CKR for managing contextual knowledge. Using the example of Figure 1, we provide in the following an overview of the features presented in the poster.



(a) Contexts

```
SELECT ?team, ?topic
WHERE {
  CONTEXT ?ctx {
    ?team a :Winner
  }
  ?ctx ckr:time 2011 ;
     ckr:topic ?topic .
}
```

?team	?topic
:barcelona	:ChampionsLeague
:barcelona	:ClubWorldCup

(b) Query

Fig. 1: CKR example.

Modelling. The CKR organizes *knowledge* in a set of OWL2 knowledge bases called *contexts* (e.g. C_1, C_2, C_3 in Figure 1a), each one annotated with a set of dimension-value pairs that describe the circumstances in which statements inside the context hold. Context annotations are stored in the *meta-knowledge*: through OWL2 RL reasoning, they are used to identify relevant *compatibility relations* holding between contexts, such as the cover relation connecting broader with narrower-scoped contexts (other relations are under investigation). Inside a context, regular OWL2 classes and properties (e.g. Winner and Team) have a *local meaning* (i.e. context-dependent), while *qualified symbols* (such as $\mathsf{Winner}_{\mathsf{ChampionsLeague}}$, $\mathsf{Team}_{\mathsf{ClubWorldCup}}$) are introduced to refer to the meaning of a class or property in a particular context, thus enabling the reference from a context to the meaning of a symbol in another context.

Reasoning. Reasoning in CKR is the mixing of two processes: *local reasoning* inside contexts and *knowledge propagation* among contexts. The first is performed using regular OWL2 RL reasoning on the local contents of contexts; the latter is based on knowledge propagation rules that exploit compatibility relations and qualified symbols. For example, the statement $\mathsf{Winner}(\mathsf{barcelona})$ in C_2 (shown in bold in Figure 1a) can be derived by applying local reasoning in C_3 to infer $\mathsf{Team}(\mathsf{barcelona})$, which is then shifted up to C_1 obtaining $\mathsf{Team}_{\mathsf{ClubWorldCup}}(\mathsf{barcelona})$; by local reasoning in C_1, $\mathsf{Winner}_{\mathsf{ChampionsLeague}}(\mathsf{barcelona})$ is derived and then shifted down into C_2 obtaining $\mathsf{Winner}(\mathsf{barcelona})$. Through a repeated application of local reasoning and knowledge propagation, the *CKR closure* operation permits to materialize all inferrable statements.

Querying. *Contextual queries* in CKR are an extension of SPARQL where the keyword CONTEXT constrains the queried context. For instance, Figure 1b presents a contextual query to extract all the winners of 2011 football competitions. Query answering is performed after the CKR closure operation is applied.

In conclusions, the poster presents how CKR features can be used for managing contextualized knowledge. Differently from other context frameworks, the CKR has both a well-founded semantics and is standard-friendly, as it is implemented by associating contexts to named graphs and CKR meta-knowledge to graph metadata. Therefore, the CKR represents an easily adoptable and workable solution for real-world SW applications needing to deal with contextualized knowledge.

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