

Description Logics for Fishery Time

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Abstract

Controlling time in fisheries is executed by analyzing data which are picked up from investigated documents to make significant decisions. When data are big enough, time information of objects definitely become hard to represent to get knowledge quickly and temporal relationships have gone more difficult for observing. This article concentrate on introducing Description Logics (DLs) which is extended by rules as an appropriate knowledge representation formalism for managing fishery time. A DL knowledge base for fisheries is installed with relations between areas and creatures, creatures and catchers, catchers and time for catching, time and opened areas, catchers and tools. To build this model, we use Protégé for illustrating an ontology of fisheries through data got from the document of Vietnamese mangrove fisheries. This document is published by Agriculture Institute of Vietnam in 2015 with statistics in detail. The research shows the way to represent fishery time by DLs.

Keywords: Description logics, Temporal fishery representation, DLs for time.

1. Introduction

Marine resources have significant biological productivity, especially value of creatures. With roles of making and growing creatures, sea has been providing the great amount of annual economic value of creatures and bringing the high power of economy for communities living by fishing.

To protect marine products, fisheries need to be managed seriously. For Kevern and Serge (2009), some of base solutions for managing fisheries showed are:

- Regulating time for opening areas and periods for each vessel in catching.
- Regulating the quantities of creatures caught in each area.
- Claiming restrictions about size of fishing tools for vessels, small crafts and fishers.

Therefore, the process of the fishery management is going to be based on some essential elements and relationships of them in order to guard diversity of species as well as sustainable productivity for fishermen. The elements in the fishery model are species, fishing tool, catcher, fishing area, time and different levels of interaction between them. However, the management always has a lot of challenges which come from complex interaction of elements in the fisheries and diversity of these elements.

The following partial list sketches some of issues with respect to each element:

- Species: All creatures have economic valuation in sea.
- Fishing tool: Some of methods mainly used in

fisheries.

- Time: Periods are suitable in fishing and protecting resources simultaneously.
- Fishing area: These areas are locations having zones for living of sea creatures.
- Catcher: Objects operate fishing gears.

Besides issues from interaction of elements and representing information, interaction of time and its representation in fisheries have also the significant part.

The article approaches DLs to describe time and its interaction in fisheries. Protégé software can be seen as a tool to transform this model into the fishery ontology for illustrating.

We arrange the article as the following structure: Description logics (section 2) are represented before knowledge base of fisheries (section 3). The next section is experiments for time fisheries in protégé (section 4) and conclusions for the last section (section 5).

2. Description logics

2.1. Overview

DLs is one of the latest terminology in a family of knowledge representation. Before a couple of words “description logics” becomes popular, it is said as phrases “knowledge representation languages” or “concept languages” (Franz et al, 2002; Franz et al, 2007).

DLs can be used to represent the conceptual knowledge of an application domain in a structured and formally well-understand way by classification of concepts and individuals. The result from

classification of concepts is subconcept/superconcept relationships (called subsumption relationships) between the concepts of a given terminology as well as acknowledgment for structuring the terminology in the form of a subsumption hierarchy. This hierarchy provides valuable information about connections of different concepts and it is able to speed up other inference services. Determining whether this instance relationship is implied by the description on the individual and the definition of the concept is the other result from classification of individuals. Furthermore, instance relationships may trigger the application of rules that insert additional facts into the knowledge base.

2.2. Knowledge bases

Knowledge representation systems based on DLs provide tools for creating knowledge bases, reasoning their contents and running them.

A DL knowledge base usually consists of two parts. The terminological part (TBox), which defines concepts and also states additional constraints on the interpretation of these concepts, and the assertional part (ABox), which describes individuals and their relationships to each other and to concepts. In addition, through reasoning services we can get right knowledge. Besides storing terminologies and assertions, DL systems also offer services that reason about them such as reasoning tasks to determine whether a description is satisfiable or whether one description is more general than another one.

2.3. Description languages

Complex concepts in DLs are built by AL (attributive language) or extend languages of AL called description languages from the family of AL-languages (Franz et al, 2002; Franz et al, 2007). Besides, there are also many languages from family of calculus with different expressive power (SHIO, SHION...) (Yu, 2008). Starting with description bases and rules for building concepts, description languages help to make new concepts in knowledge based systems.

2.3.1. Basic description language AL

$C, D \rightarrow A$	(atomic concept)
$\top$	(universal concept)
$\perp$	(bottom concept)
$\neg A$	(atomic negation)
$C \sqcap D$	(intersection)
$\forall R.C$	(value restriction)
$\exists R.T$	(limited existential quantification)

Table 1. The syntax rule of attributive language

Basic elements of the AL are concepts and roles of atomic concepts. Complex descriptions are

formed by associations of the elements through constructors. In abstract notation, the letters A and

B are used for atomic concepts, the letter R for atomic roles, and the letter C and D for concept descriptions. Concept descriptions in AL are formed according to the following syntax rules in Table 1. (Franz et al, 2002).

2.3.2. The family of AL languages

The Figure 1 lists some elements of the family AL-languages (Yu, 2008). ALC is a combination between three letters in which the letters AL stand for attributive language and the letter C for complement. Besides ALC, other letters indicate various DL extensions including the following:

- I for inverse roles.
- F for functional restrictions.
- H for role hierarchy
- Q for qualified number restrictions

Description Languages Name	Propositional constructs	Universal/ Existential Restriction	Functional Restriction	Qualified Number Restriction	Role Hierarchy	Inverse Role	Transitive Role	Nominal
	$\sqcap$ $\sqcup$ $\neg$	$\forall R.C$ $\exists R.C$	$\exists \leq 1R$ $\exists \geq 1R$	$\exists \leq nR.C$ $\exists \geq nR.C$	$R_1 \sqsubseteq R_2$	R^-	S	{o}
ALC	✓	✓						
ALCI	✓	✓				✓		
ALCFI	✓	✓	✓			✓		✓
ALCHI	✓	✓		✓	✓	✓		

Figure 1. Some language elements of the family AL-languages

3. The fishery knowledge base

In this section, a knowledge base for fisheries is launched with DLs. Foundations of fisheries are represented in the TBox T. The ABox A attaches information about fishing activities in Vietnamese mangrove forests from the documentary about fisheries (Nguyen et al, 2015). It is later enhanced by new assertion obtained through ABox inference. The description of the rule base R for inferring will be shown here.

3.1 TBox

The fishery knowledge base which is a collection of definitions of concepts of fisheries, their relations and inclusion relations between the concepts. Those concepts are creature, tool, area, catcher and time. Basically, marine creatures consists of fish, crustacean and mollusc (Nguyen et al, 2015). Crustacean has three groups being crab, shrimp and prawn (Marine Education Society of Australasia, 2015) as a number of mollusc groups namely shellfish, snail and squid (Malaysia Biodiversity Information System, 2015).

Hierarchy All axiom concepts are arranged in different levels of a specialization structure is called a hierarchy. A hierarchy of fisheries is illustrated as a diagram in Figure 2(a). Each group of creatures contains another lower level of its as representative information.

Inclusions are described on the following way. For example, “All fish is creatures”

$$\text{Fish} \sqsubseteq \text{Creature}$$

A concept is equivalent to composition of other concepts below it in the hierarchy is represented through sufficient conditions for being that concept.

The description of “A fauna consists of fish, shrimp, squid, sea snail, shellfish and crab” is:

$$\text{Fauna} \equiv \text{Crustacean} \sqcup \text{Fish} \sqcup \text{Mollusc}$$

Disjoints between subconcepts can be clearly expressed. “Mollusc is disjoint with Fish and Crustacean”

$$\text{Mollusc} \equiv \neg \text{Fish} \sqcap \neg \text{Crustacean}$$

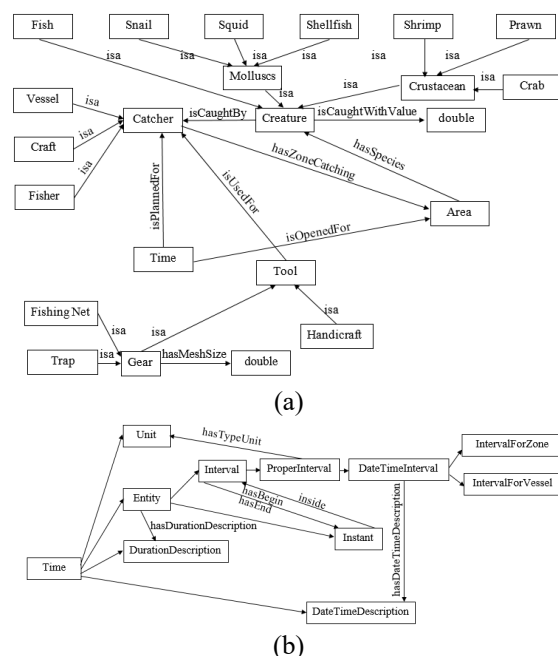


Figure 2. Fisheries TBox; (a) Hierarchy, (b) Subsumption hierarchy

Time representation Time is the indefinite continued progress of existence and events in the past, present, and future regarded as a whole. Time is formed by instants and intervals while intervals are periods between beginning instants and ending instants. There are many instants being inside an interval. Normally, intervals have positive values, the zero value is specify for two instants overlapping each other. In this research, only positive time intervals are considered as figure 2(b). Besides, each time period has to have units itself.

Description of duration is used for representing intervals with time arguments in annual fishing cycle. For example, an interval may

have duration as 2 days, or 1 day and 10 hours, or 1 month.

Description of date time is used for specifying exact time to intervals that have positive time length through its subconcepts (12 months).

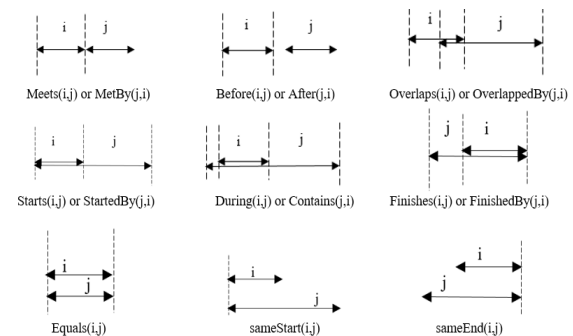


Figure 3. Relationships between of intervals

Relations between intervals can be seen in figure 3. Their relative orientations are illustrated on the time line with two intervals namely i and j . A description of the arrangement of an temporal individual with respect to another comprises ABox role, assertions.

Restrictions By using concepts and time roles, restrictions are formulated on the set of possible models. The restrictions are divided into two groups: time restrictions and fishery building regulations. First, the time restrictions are written in DLs as follows:

“An interval has starting and ending instants”

$$\text{Interval} \sqsubseteq \exists \text{hasEnd. Instant} \sqcap \exists \text{hasBegin. Instant}$$

“All instants are inside intervals”

$$\text{Instant} \sqsubseteq \forall \text{inSide. Interval}$$

“Each entity has a description about duration with time arguments”

$$\text{Entity} \sqsubseteq \exists \text{hasDurationDescription. DurationDescription}$$

“Each date time interval has a description about its date time”

$$\text{DateTimeInterval} \sqsubseteq \exists \text{hasDateTimeDescription. DateTimeDescription}$$

“Every proper intervals at least one unit”

$$\text{ProperInterval} \sqsubseteq \exists \text{hasTypeUnit. Unit}$$

Second, the fishery building regulations represented are:

“Total of time periods for catching of each vessel is greater than 1 and less than 4”

$\text{TotalForVessel} \sqsubseteq \exists_{\geq 1} (\text{Starts.IntervalForVessel}$

$\sqcap \exists_{\leq 4} \text{Starts.IntervalForVessel}$

or

$\text{TotalForVessel} \sqsubseteq$

$\exists_{\geq 1} (\text{Finishes.IntervalForVessel}$

$\sqcap \exists_{\leq 4} \text{Finishes.IntervalForVessel}$

“Time periods for vessels are during time of zones”

$\text{IntervalForVessel} \sqsubseteq \forall \text{During.IntervalForZone}$

“Intervals for vessels do not overlap, are not before and not after intervals for zones”

$\text{IntervalForVessel} \sqsubseteq$

$\neg \text{Overlap.IntervalForZone} \sqcap$

$\neg \text{Before.IntervalForZone} \sqcap$

$\neg \text{After.IntervalForZone}$

“Starting interval of a zone is the same as or before one of starting interval of vessels”

$\text{SIntervalForZone} \sqsubseteq$

$\exists \text{sameStart.SIntervalForVessel} \sqcup$

$\exists \text{Before.SIntervalForVessel}$

“Ending interval of a zone is the same as or after one of ending interval of vessels”

$\text{EIntervalOfZone} \sqsubseteq$

$\exists \text{sameEnd.EIntervalOfVessel} \sqcup$

$\exists \text{After.EIntervalOfVessel}$

Besides managing fisheries involves many restrictions, regulating the quantity of fish caught is one of the restrictions for insuring sustainable and responsible fisheries. Regulating type of gear and its size as well as specifying closed seasons and closed areas is incredibly important restrictions to protect sustainable utilization of the resources.

3.2. ABox

A delegate chosen from the statistic document published about the fisheries at Vietnamese (Nguyen et al, 2015) to illustrate ABox is the information of *Metapenaeus Affinis*, a type of prawn caught at Hung Hoa, an area of mangroves in Vietnam. Temporal individuals are supposed optional inputs and their relationships are built to support for inferring through rules.

In Hung Hoa, *Metapenaeus Affinis* is caught by vessels and crafts having gears (gill-net, drift-net, weir and cage) at Hoa Lam and Phong Dang with opened time from Febuary until June and from October to November, respectively. (Nguyen et al, 2015). The opened time of Hoa Lam and Phong Dang is intervals, namely interval_{0206} and interval_{1010} . Supposing Vessel1, Vessel2, Vessel3

and Vessel4 caught at Hoa Lam. Vessel1 caught 5.4 kg in interval_{0203} , Vessel2 caught in interval_{0305} , Vessel3 caught in interval_{0405} and Vessel4 caught in interval_{0406} . From these details, a small part of ABox is:

$A = \{$ *Metapenaeus affinis* : prawn,
 HungHoa : area,
 Vessel1, Vessel2, Vessel3 : vessel,
 HoaLam, PhongDang : zone,
 (*Metapenaeus affinis, HungHoa*):
isSpeciesOf,
 (*HungHoa, HoaLam*) : hasPart,
 (*interval₀₂₀₆, HoaLam*) : isOpenedFor,
 (*interval₀₂₀₃, Vessel1*) : isPlannedFor,
 (*interval₀₂₀₆, interval₁₀₁₁*) : before,
 (*interval₀₂₀₃, interval₀₄₀₅*) : meet,
 (*interval₀₂₀₃, interval₀₃₀₄*) : overlap,
 (*interval₀₃₀₄, interval₀₂₀₅*) : during,
 (*interval₀₁₀₃, interval₀₃₀₄*) : start,
 (*interval₃₀₀₄, interval₀₃₀₄*) : finish,
 ...}

“Metapenaeus affinis in Hung Hoa is caught at HoaLam and PhongDang”

MetapenaeusAffinisInHungHoa: isSpeciesOf.
(*HoaLam* $\sqcup$ *PhongDang*)

“Vessel1 catches 5.4 kg for Metapenaeus Affinis at HoaLam”

Vessel1: caught. *MetapenaeusAffinis*

$\sqcap = 5.4$ isCaughtWithValue

$\sqcap$ hasZoneCatching. *HoaLam*

“Interval₀₂₀₃ for Vessel1 overlaps interval₀₃₀₄ for Vessel2”.

$\text{Interval}_{0203} \sqsubseteq \text{Overlaps.Interval}_{0305}$

“Interval₀₂₀₃ for Vessel1 is before interval₀₄₀₅ for Vessel3 ”

$\text{Interval}_{0203} \sqsubseteq \text{Meets.Interval}_{0405}$

3.3. Rules

From the time relationships represented, temporal rules can be created to serve for managing fisheries:

“If an interval x_3 meets intervals x_1 and x_2 , represented with relationship sameStart(x_1, x_2)”

(x_1, x_2) : sameStart $\leftarrow$

(x_3, x_1) : Meets $\wedge$ (x_3, x_2) : Meets $\wedge$ x_1 : Interval
 $\wedge$ x_2 : Interval $\wedge$ x_3 : Interval

“If an interval x_3 before an interval x_1 and the interval x_1 is before an interval x_2 . So the interval x_3 is before the interval x_2 and represented with relationship Before(x_3, x_2)”

(x_3, x_2) : Before $\leftarrow$

(x_3, x_1) : Before $\wedge$ (x_1, x_2) : Before $\wedge$ x_1 : Interval
 $\wedge$ x_2 : Interval $\wedge$ x_3 : Interval

“If an interval x_1 has finishing interval k , x_1 is during an interval x_2 , x_1 and x_2 have the same ending interval. Therefore, x_2 has also fishing interval k , represented with relationship $Finishes(k, x_2)$ ”

$(k, x_2): \text{Finishes} \leftarrow$
 $(k, x_1): \text{Finishes} \wedge (x_1, x_2): \text{During}$
 $\wedge (x_1, x_2): \text{sameEnd} \wedge x_1: \text{Interval} \wedge x_2: \text{Interval}$
 $\wedge k: \text{Interval}$

Some other rules for fishing can also be showed below:

“If a species lives in an area, this species certainly lives in the superconcept of the area”

$(x_1, x_3): \text{hasSpecies} \leftarrow$
 $x_1: \text{Area} \wedge x_2: \text{Area} \wedge x_3: \text{Creature}$

“If x_1 is one of the following elements: Fishing net (drag-net, gill-net); trap (cage, drift-net, weir); handicraft (spear, harpoon), x_1 becomes a fishing tool.”

$x_1: \text{Trap} \vee x_1: \text{Handicraft}$

can be rewrited is:

$x_1: \text{Tool} \leftarrow$
 $x_1: \text{fishingNet} \vee x_1: \text{Trap} \vee x_1: \text{Handicraft}$

“The species which is crab is also Crustacean” is:
 $\text{hasPart}(?z, ?y) \leftarrow x: \text{Crab} \wedge y: \text{Creature} \wedge$
 $z: \text{Crustacean} \wedge \text{hasPart}(?z, ?x) \wedge$
 $\text{hasPart}(?x, ?y)$

4. Experiments

In this section, we use Protégé version 4.3 - a free, open source platform to represent the knowledge base that are described above. Information about fisheries in Vietnam (Nguyen et al, 2015) are the background to build an ontology of fisheries. After that, temporal rules are built to infer relationships of relevant interval and instant elements.

Example 1. If interval i meets interval j , then j and k have the same starting interval, represented with relationship $\text{Meets}(i, k)$.

Rule statement:

$\text{Meets}(?i, ?j), \text{sameStart}(?j, ?k) \rightarrow \text{Meets}(?i, ?k)$

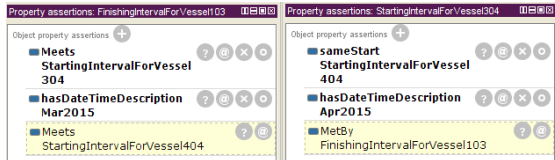


Figure 4. Result for example 1

Example 2. If an interval i meets interval k and overlaps interval j , then interval j and interval k have the same ending interval, $\text{During}(k, j)$ is the

relationship for representation.

Rule statement:

$\text{Meets}(?i, ?k), \text{Overlaps}(?i, ?j), \text{sameEnd}(?j, ?k)$
 $\rightarrow \text{During}(?k, ?j)$

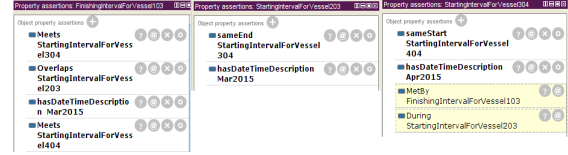


Figure 5. Result for example 3

Example 4. If interval i and j have the same starting interval, intervals i and j have all the same durations with units (month, week, day) respectively, $\text{sameEnd}(?j, ?i)$ is represented for this relationship.

Rule statement:

$\text{hasUnitType}(?i, \text{unitMonth}), \text{hasUnitType}(?i, \text{unitWeek}), \text{hasUnitType}(?j, \text{unitDay}),$
 $\text{hasUnitType}(?j, \text{unitMonth}), \text{hasUnitType}(?j, \text{unitWeek}), \text{sameStart}(?i, ?j), \text{days}(?i, ?l), \text{days}(?j, ?l),$
 $\text{months}(?i, ?m), \text{months}(?j, ?m), \text{weeks}(?i, ?k), \text{weeks}(?j, ?k) \rightarrow \text{sameEnd}(?j, ?i)$

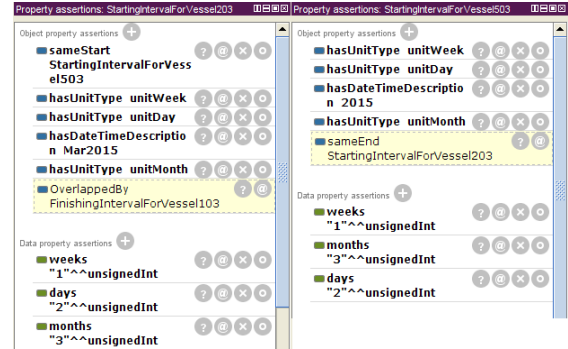


Figure 6. Result for example 4

5. Conclusions

In this research, we proposed an approach to DLs for time in fisheries. This model describes relationships between of two temporal objects. From here, there are many relationships between other temporal objects can be reasoned by rules. After denoting the fishery knowledge base into Protégé for experiments, we get some favorable results about reasonings for temporal relationships. We believe this contribution can be solve problems about representing temporal objects and relationships between of them in fisheries.

6. Acknowledgements

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7. References

- Franz, B., Deborah, L.M., Daniele, N., & Peter F.P. (2002). *Description Logic HandBook: Theory, Implementation and Applications*. Cambridge University Press.
- Franz, B., Iran, H., & Ulrike, S. (2007). *Description Logics*. In: F. Van Harmelen, V. Lifschitz and B. Porter, editors. *Handbook of knowledge representation*. Elsevier.
- Kevern, L.C., & Serge, M.G. (2009). *A fishery manager's guidebook*. The Food and Agriculture Organization of the United Nations and Wiley – Blackwell.
- Malaysia Biodiversity Information System. Marine and coastal biodiversity (2015). Available from: <https://www.mybis.gov.my/art/6>, March 14, 2018.
- Marine Education Society of Australasia. Animals of mangroves (2015). Available from: <http://www.mesa.edu.au/mangroves/mangroves05.asp>, March 14, 2018.
- Nguyen, Q.H., Do, A.D., Luu, X.H. & Hoang, D.C. (2015) *Biodiversity and aquatic resources in the mangrove ecosystem of Vietnam*. Agriculture Institute of Vietnam.
- Yu, D. (2008). *Tableau – based reasoning for description logics with inverse roles and number restrictions* (doctoral dissertation). Concordia university.