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## THE EXPERTISE ONTOLOGY 1.0

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### DL AXIOMS

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## 1 Topic and Modeling Topic Hierarchy

### 1.1 Topic

The schema diagram in Figure 1 shows how topics are organized and related through three relations: `hasSubTopic` and its inverse `isSubTopicOf`, and `hasRelatedTopic`. The `hasSubTopic` relationship is transitive and denotes that one topic is the parent of another. Specialized relationships between topics are denoted using `hasRelatedTopic`, a symmetric relation.

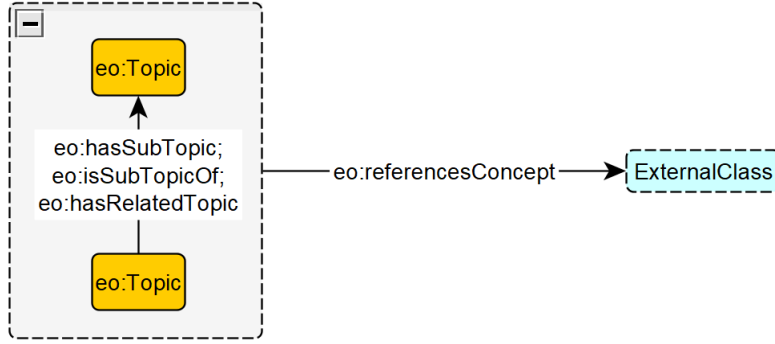


Figure 1: Schema diagram for the Topic class and inter-relationships.

#### Axioms:

- $$\begin{aligned}
 & \text{Topic} \sqsubseteq \forall \text{hasSubTopic} . \text{Topic} & (1) \\
 & \exists \text{hasSubTopic} . \text{Topic} \sqsubseteq \text{Topic} & (2) \\
 & \text{Topic} \sqsubseteq \forall \text{isSubTopicOf} . \text{Topic} & (3) \\
 & \exists \text{isSubTopicOf} . \text{Topic} \sqsubseteq \text{Topic} & (4) \\
 & \text{Topic} \sqsubseteq \forall \text{hasRelatedTopic} . \text{Topic} & (5) \\
 & \exists \text{hasRelatedTopic} . \text{Topic} \sqsubseteq \text{Topic} & (6) \\
 & \text{hasSubTopic} \equiv \text{isSubTopicOf}^{-} & (7) \\
 & \text{hasSubTopic} \sqsubseteq \text{hasSubTopic} & (8) \\
 & \text{hasRelatedTopic} \equiv \text{hasRelatedTopic}^{-} & (9) \\
 & \exists \text{referencesConcept} . \text{Topic} \sqsubseteq \text{Topic} & (10)
 \end{aligned}$$

#### Explanation of axioms:

1. Scoped Range: The scoped range of `hasSubTopic`, scoped by `Topic`, is `Topic`.
2. Scoped Domain: The scoped domain of `hasSubTopic`, scoped by `Topic`, is `Topic`.
3. Scoped Range: The scoped range of `isSubTopicOf`, scoped by `Topic`, is `Topic`.
4. Scoped Domain: The scoped domain of `isSubTopicOf`, scoped by `Topic`, is `Topic`.
5. Scoped Range: The scoped range of `hasRelatedTopic`, scoped by `Topic`, is `Topic`.
6. Scoped Domain: The scoped domain of `hasRelatedTopic`, scoped by `Topic`, is `Topic`.
7. Inverse: `hasSubTopic` is the inverse relation of `isSubTopicOf`.
8. Transitive: `hasSubTopic` is a transitive relation.
9. Symmetric: `hasRelatedTopic` is a symmetric relation.
10. Scoped Domain: The scoped domain of `referencesConcept`, scoped by `Topic`, is `Topic`.

### 1.2 TopicConnectednessDescription

Because we only have two formal types of relations, denoting hierarchical and relatedness relationships between topics, we follow standard reification using the `TopicConnectednessDescription` (TCD) class to

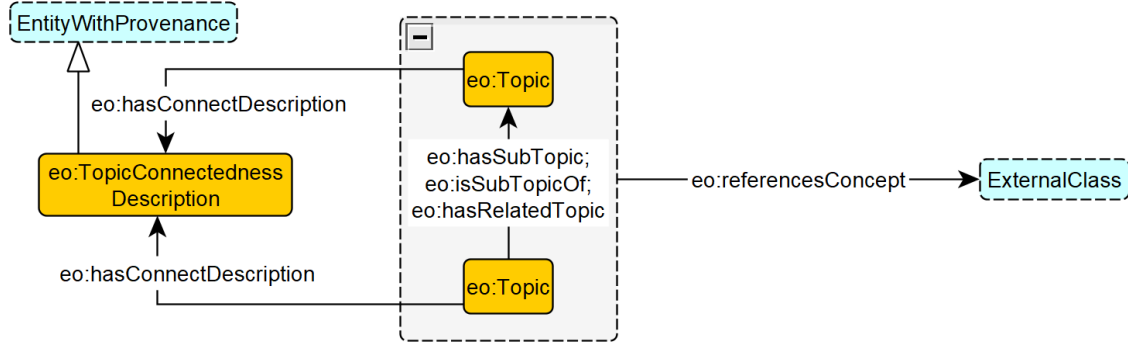


Figure 2: Schema diagram for the TopicConnectednessDescription class.

encode other semantics such as specific semantics of relationships, provenance, reference to external classes, etc. One can also choose to link topic instances to their corresponding class in an external ontology using metadata properties such as `rdfs:label`, `eo:referencesConcept`, etc.

#### Axioms:

$$\text{TCD} \sqsubseteq \forall \text{hasConnectDescription}.\text{Topic} \quad (11)$$

$$\exists \text{hasConnectDescription}.\text{TCD} \sqsubseteq \text{Topic} \quad (12)$$

$$\text{TCD} \sqsubseteq \geq 2 \text{ hasConnectDescription}^{\perp}.\text{Topic} \quad (13)$$

#### Explanation of axioms:

11. Scoped Range: The scoped range of `hasConnectDescription`, scoped by TCD, is Topic.
12. Scoped Domain: The scoped domain of `hasConnectDescription`, scoped by Topic, is TCD.
13. Existential and Functionality: Every TCD records the description between at least two topics.

## 2 Asserting their expertise

### 2.1 Expert

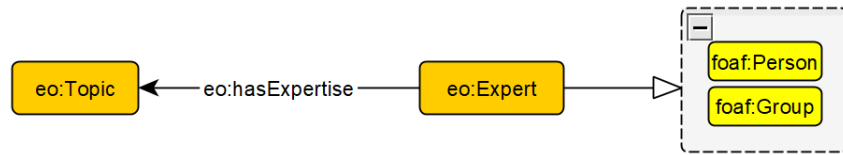


Figure 3: Schema diagram representing

#### Axioms:

$$\text{Expert} \sqsubseteq \text{foaf:Person} \vee \text{foaf:Group} \quad (14)$$

$$\text{Topic} \sqsubseteq \forall \text{hasExpertise}.\text{Expert} \quad (15)$$

$$\exists \text{hasExpertise}.\text{Topic} \sqsubseteq \text{Expert} \quad (16)$$

$$\text{Topic} \sqsubseteq \exists \text{hasExpertise}.\text{Expert} \quad (17)$$

#### Explanation of axioms:

14. Subclass: Every Expert is either a `foaf:Person` or a `foaf:Group`.
15. Scoped Range: The scoped range of `hasExpertise`, scoped by Topic, is Expert.
16. Scoped Domain: The scoped domain of `hasExpertise`, scoped by Expert, is Topic.
17. Existential: Every Expert has expertise in at least one topic.

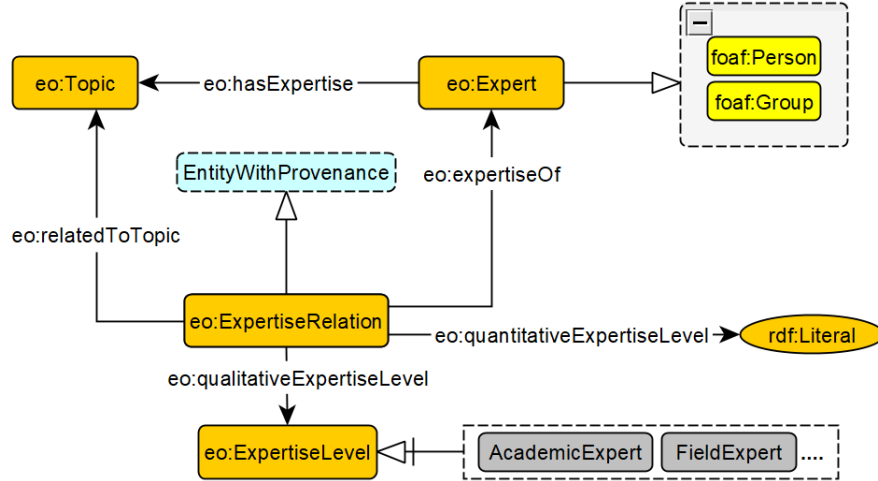


Figure 4: Schema diagram representing .

## 2.2 ExpertiseRelation

### Axioms:

- $$\begin{aligned} \text{ExpertiseRelation} &\sqsubseteq \forall \text{relatedToTopic} . \text{Topic} & (18) \\ \exists \text{relatedToTopic} . \text{ExpertiseRelation} &\sqsubseteq \text{Topic} & (19) \\ \text{ExpertiseRelation} &\sqsubseteq \exists \text{relatedToTopic} . \text{Topic} & (20) \\ \text{ExpertiseRelation} &\sqsubseteq \exists \text{relatedToTopic}^{-} . \text{ExpertiseRelation} & (21) \\ \text{ExpertiseRelation} &\sqsubseteq \forall \text{expertiseOf} . \text{Expert} & (22) \\ \exists \text{expertiseOf} . \text{ExpertiseRelation} &\sqsubseteq \text{Expert} & (23) \\ \text{ExpertiseRelation} &\sqsubseteq \exists \text{expertiseOf} . \text{Expert} & (24) \\ \text{ExpertiseRelation} &\sqsubseteq \exists \text{expertiseOf}^{-} . \text{ExpertiseRelation} & (25) \\ \exists \text{quantitativeEL} . \text{ExpertiseRelation} &\sqsubseteq \text{rdf:Literal} & (26) \\ \text{ExpertiseRelation} &\sqsubseteq \forall \text{qualitativeEL} . \text{ExpertiseLevel} & (27) \\ \exists \text{qualitativeEL} . \text{ExpertiseLevel} &\sqsubseteq \text{ExpertiseRelation} & (28) \end{aligned}$$

### Explanation of axioms above:

18. Scoped Range: The scoped range of relatedToTopic, scoped by AER, is Topic.
19. Scoped Domain: The scoped domain of relatedToTopic, scoped by AER, is Topic.
20. Existential: Every instance of ExpertiseRelation is related to at least one topic.
21. Existential: The inverse filler of relatedToTopic must exist and must be a ExpertiseRelation.
22. Scoped Range: The scoped range of expertiseOf, scoped by AER, is Expert.
23. Scoped Domain: The scoped domain of expertiseOf, scoped by AER, is Expert.
24. Existential: Every instance of ExpertiseRelation is related to at least one expert.
25. Existential: The inverse filler of expertiseOf must exist and must be a ExpertiseRelation.
26. Domain: The domain of quantitativeEL is ExpertiseRelation.
27. Scoped Range: The scoped range of qualitativeEL, scoped by ExpertiseRelation, is ExpertiseLevel.
28. Scoped Domain: The scoped domain of hasExpertise, scoped by ExpertiseLevel, is ExpertiseRelation.

## 2.3 Affiliation

### Axioms:

- $$\begin{aligned} \text{Affiliation} &\sqsubseteq \forall \text{affiliationWith} . \text{Organization} & (29) \\ \exists \text{affiliationWith} . \text{Organization} &\sqsubseteq \text{Affiliation} & (30) \end{aligned}$$

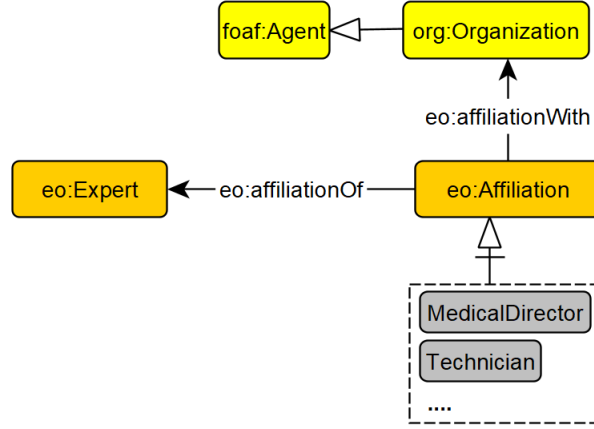


Figure 5: Schema diagram representing

**Explanation of axioms above:**

29. Scoped Range: The scoped range of affiliationWith, scoped by Affiliation, is Organization.  
 30. Scoped Domain: The scoped domain of affiliationWith, scoped by Organization, is Affiliation.

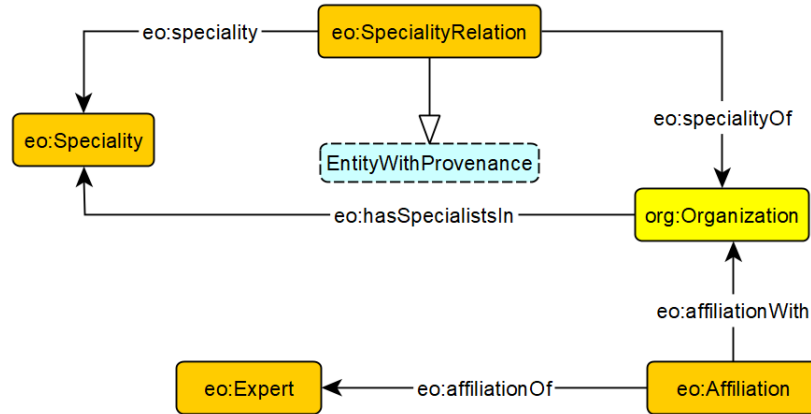
**2.4 Speciality and SpecialityRelation**

Figure 6: Schema diagram representing

**Axioms:**

- $$\begin{aligned} \text{Organization} &\sqsubseteq \forall \text{hasSpecialistsIn}.\text{Speciality} & (31) \\ \exists \text{hasSpecialistsIn}.\text{Speciality} &\sqsubseteq \text{Organization} & (32) \\ \text{SpecialityRelation} &\sqsubseteq \forall \text{specialityOf}.\text{Organization} & (33) \\ \exists \text{specialityOf}.\text{Organization} &\sqsubseteq \text{SpecialityRelation} & (34) \\ \text{SpecialityRelation} &\sqsubseteq \exists \text{specialityOf}.\text{Organization} & (35) \\ \text{SpecialityRelation} &\sqsubseteq \exists \text{specialityOf}^{\perp}.\text{SpecialityRelation} & (36) \\ \text{SpecialityRelation} &\sqsubseteq \forall \text{speciality}.\text{Speciality} & (37) \\ \exists \text{speciality}.\text{Speciality} &\sqsubseteq \text{SpecialityRelation} & (38) \\ \text{SpecialityRelation} &\sqsubseteq \exists \text{speciality}.\text{Speciality} & (39) \\ \text{SpecialityRelation} &\sqsubseteq \exists \text{speciality}^{\perp}.\text{SpecialityRelation} & (40) \end{aligned}$$

**Explanation of axioms above:**

31. Scoped Range: The scoped range of hasSpecialistsIn, scoped by Organization, is Speciality.

32. Scoped Domain: The scoped domain of hasSpecialistsIn, scoped by Speciality, is Organization.
33. Scoped Range: The scoped range of specialityOf, scoped by SpecialityRelation, is Organization.
34. Scoped Domain: The scoped domain of specialityOf, scoped by Organization, is SpecialityRelation.
35. Existential: Every instance of SpecialityRelation is related to at least one organization.
36. Existential: The inverse filler of specialityOf must exist and must be a SpecialityRelation.
37. Scoped Range: The scoped range of speciality, scoped by SpecialityRelation, is Speciality.
38. Scoped Domain: The scoped domain of speciality, scoped by Speciality, is SpecialityRelation.
39. Existential: Every instance of SpecialityRelation is related to at least one speciality.
40. Existential: The inverse filler of speciality must exist and must be a SpecialityRelation.

## 2.5 Activity and ActivityRelation

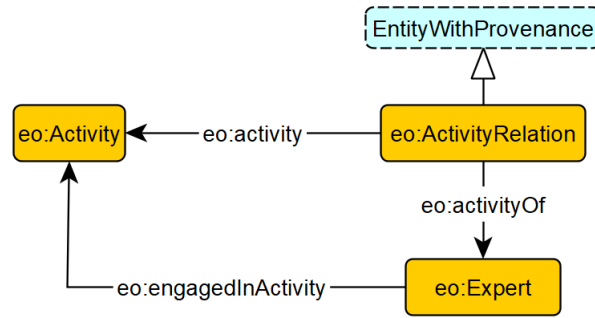


Figure 7: Schema diagram representing three avenues of modeling expertise for experts. Color and shape usage is the same as in the previous diagram. In addition, grey boxes with a dashed border represent controlled vocabularies (i.e., classes that have been defined as a specific set of individuals). Orange ellipses are literals.

**Axioms:**

- $$\begin{aligned}
 \text{Expert} &\sqsubseteq \forall \text{engagedInActivity}. \text{Activity} & (41) \\
 \exists \text{engagedInActivity}. \text{Activity} &\sqsubseteq \text{Expert} & (42) \\
 \text{ActivityRelation} &\sqsubseteq \forall \text{activityOf}. \text{Expert} & (43) \\
 \exists \text{activityOf}. \text{Expert} &\sqsubseteq \text{ActivityRelation} & (44) \\
 \text{ActivityRelation} &\sqsubseteq \exists \text{activityOf}. \text{Expert} & (45) \\
 \text{ActivityRelation} &\sqsubseteq \exists \text{activityOf}^{\perp}. \text{ActivityRelation} & (46) \\
 \text{ActivityRelation} &\sqsubseteq \forall \text{activity}. \text{Activity} & (47) \\
 \exists \text{activity}. \text{Activity} &\sqsubseteq \text{ActivityRelation} & (48) \\
 \text{ActivityRelation} &\sqsubseteq \exists \text{activity}. \text{Activity} & (49) \\
 \text{ActivityRelation} &\sqsubseteq \exists \text{activity}^{\perp}. \text{ActivityRelation} & (50)
 \end{aligned}$$

**Explanation of axioms above:**

41. Scoped Range: The scoped range of engagedInActivity, scoped by Expert, is Activity.
42. Scoped Domain: The scoped domain of engagedInActivity, scoped by Activity, is Expert.
43. Scoped Range: The scoped range of activityOf, scoped by ActivityRelation, is Expert.
44. Scoped Domain: The scoped domain of activityOf, scoped by Expert, is ActivityRelation.
45. Existential: Every instance of ActivityRelation is related to at least one expert.
46. Existential: The inverse filler of activityOf must exist and must be a ActivityRelation.
47. Scoped Range: The scoped range of activity, scoped by ActivityRelation, is Activity.
48. Scoped Domain: The scoped domain of activity, scoped by Activity, is ActivityRelation.
49. Existential: Every instance of ActivityRelation is related to at least one activity.
50. Existential: The inverse filler of activity must exist and must be a ActivityRelation.

### 3 Annotating Knowledge Graph Content with Topics

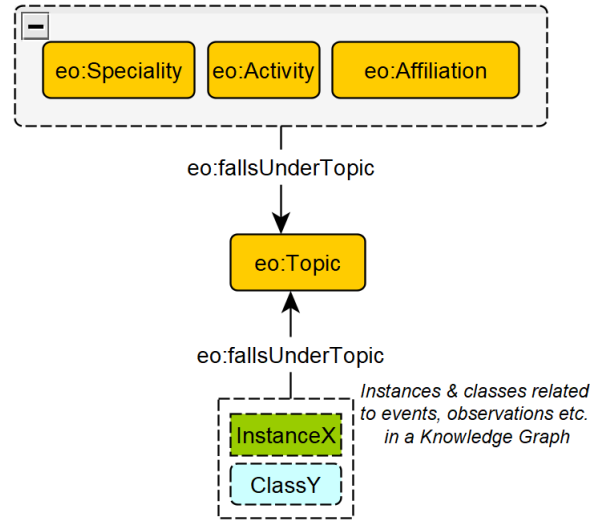


Figure 8: Schema diagram representing .

**Axioms:**

$$T \sqsubseteq \forall \text{fallsUnderTopic} . \text{Topic} \quad (51)$$

$$\text{fallsUnderTopic} \circ \text{isSubTopicOf} \sqsubseteq \text{fallsUnderTopic} \quad (52)$$

**Explanation of axioms above:**

51. Range: The scoped range of `fallsUnderTopic` is `Topic`.

52. Property chain: (cannot be expressed in OWL DL).

### 4 Spatial Scoping

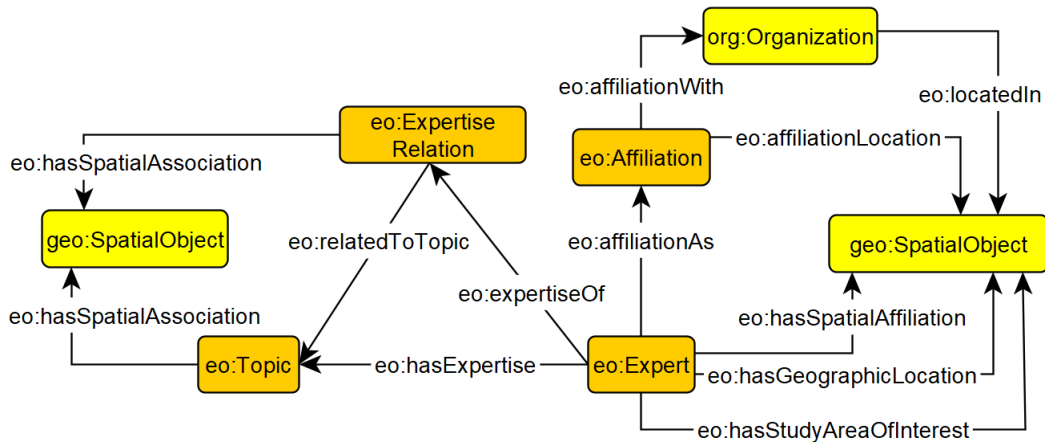


Figure 9: Schema diagram showing the different ways in which expertise is spatially scoped.



**Axioms:**

$$\exists \text{hasGeoLocation.geo:SpatialObject} \sqsubseteq \text{Expert} \quad (53)$$

$$\text{Expert} \sqsubseteq \forall \text{hasGeoLocation.geo:SpatialObject} \quad (54)$$

$$\exists \text{locatedIn.geo:SpatialObject} \sqsubseteq \text{Organization} \quad (55)$$

$$\text{Organization} \sqsubseteq \forall \text{locatedIn.geo:SpatialObject} \quad (56)$$

$$\exists \text{hasStudyAOI.geo:SpatialObject} \sqsubseteq \text{Expert} \quad (57)$$

$$\text{Expert} \sqsubseteq \forall \text{hasStudyAOI.geo:SpatialObject} \quad (58)$$

$$\top \sqsubseteq \forall \text{hasSpatialAsstn.geo:SpatialObject} \quad (59)$$

$$\exists \text{hasSpatialAsstn.geo:SpatialObject} \sqsubseteq \text{ExpertiseRelation} \vee \text{Topic} \quad (60)$$

**Note:** Here, we use `hasGeoLocation`, `hasStudyAOI` and `hasSpatialAsstn` in place of `hasGeographicLocation`, `hasStudyAreaOfInterest` and `hasSpatialAssociation` respectively.

**Explanation of axioms above:**

- 53. Scoped Range: The scoped range of `hasGeoLocation`, scoped by `geo:SpatialObject`, is `Expert`.
- 54. Scoped Domain: The scoped domain of `hasGeoLocation`, scoped by `Expert`, is `geo:SpatialObject`.
- 55. Scoped Range: The scoped range of `locatedIn`, scoped by `geo:SpatialObject`, is `Organization`.
- 56. Scoped Domain: The scoped domain of `locatedIn`, scoped by `Organization`, is `geo:SpatialObject`.
- 57. Scoped Range: The scoped range of `hasStudyAOI`, scoped by `geo:SpatialObject`, is `Expert`.
- 58. Scoped Domain: The scoped domain of `hasStudyAOI`, scoped by `Expert`, is `geo:SpatialObject`.
- 59. Range: The scoped range of `hasSpatialAsstn` is `geo:SpatialObject`.
- 60. Scoped Domain: The scoped domain of `hasSpatialAsstn`, scoped by `geo:SpatialObject`, is either `ExpertiseRelation` or `Topic`.

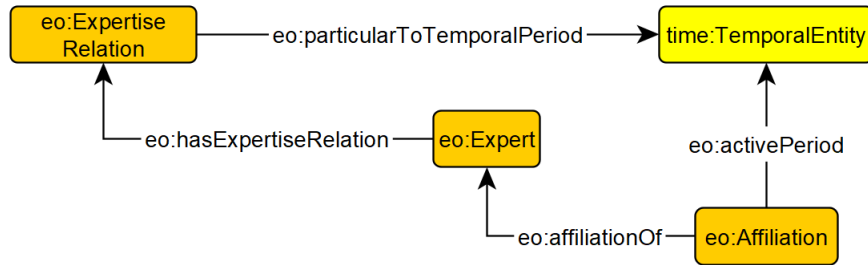
**5 Temporal Scoping**

Figure 10: Schema diagram showing the different ways in which expertise is temporally scoped.

**Axioms:**

$$\top \sqsubseteq \forall \text{particularToTP.time:TemporalEntity} \quad (61)$$

$$\exists \text{particularToTP.time:TemporalEntity} \sqsubseteq \text{ExpertiseRelation} \vee \text{ActivityRelation} \quad (62)$$

$$\text{Affiliation} \sqsubseteq \forall \text{activePeriod.time:TemporalEntity} \quad (63)$$

$$\exists \text{activePeriod.time:TemporalEntity} \sqsubseteq \text{Affiliation} \quad (64)$$

**Note:** Here, we use `particularToTP` in place of `particularToTemporalPeriod`.

**Explanation of axioms above:**

- 61. Range: The range of `particularToTP` is `time:TemporalEntity`.
- 62. Scoped Domain: The scoped domain of `particularToTP`, scoped by `Expert`, is either `ExpertiseRelation` or `ActivityRelation`.
- 63. Scoped Range: The scoped range of `locatedIn`, scoped by `time:TemporalEntity`, is `Affiliation`.
- 64. Scoped Domain: The scoped domain of `activePeriod`, scoped by `Affiliation`, is `time:TemporalEntity`.