CRMinf
Argumentation model

Definition of the CRMinf
An Extension of CIDOC CRM to support argumentation

Approved by the CIDOC CRM-SIG

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Introduction

This document presents CRMinf, an extension of the CIDOC Conceptual Reference Model (CRM, ISO 21127) created to support the documentation of scholarly and scientific arguments for documented propositions about the past. As such, it constitutes a formal ontology of epistemological processes. The making of documented propositions and their arguments are seen as historical facts regardless of their relevance. The purpose of documenting the argumentation is safeguarding and understanding the provenance of knowledge, for future assessments of authenticity and for providing sufficient information for reassessing the validity of an argument and its conclusions based on given or new evidence of whatever kind. CRMinf does not aim at promoting the application of formal logical reasoning about historical facts or replacing scholarly arguments by automation. Even though the results of formal logical reasoning can be documented in CRMinf, it rather commits to an epistemology of "inference to the best explanation (IBE)" (Ladyman, 2002).

Scope

CRMinf regards as "knowledge" anything someone says and can justify as "I know that X", regardless of whether X is regarded to be true, false, probable, etc., whereas X itself is regarded as information or "data". In this sense, knowledge resides in humans, who relate the symbols in information to states of affairs in current or past reality. "Knowledge representation" is regarded as a particular form of encoded information, for instance a CRM-compatible form. CRMinf aims at connecting the people who know something to the information representing their knowledge, and its justification. The model supposes scientific ethics and is not concerned with beliefs of people using CRMinf differently from what they state, but it can quite well be used to reason about deliberately false statements in historical sources.

The disciplines addressed by CRMinf are what (Turner, 2012) calls "historical sciences", i.e., cultural heritage studies, human and natural history, archaeology, but also descriptive empirical sciences, such as biodiversity, ethnology, geology, cultural heritage conservation, even clinical studies, etc., in their focus on documenting particular states of affairs now and in the past.

CRMinf is inspired by the IAM model in Doerr, Kritsotaki and Boutsika (2011), which in turn draws on a background of other argumentation models under the aspect of application to *knowledge about the past*, among them being the "logicist" approach (Gardin, 2003), (Gardin & Roux, 2004) in use in France for archaeological data. Like the IAM, CRMinf deals with the sources of knowledge for facts stated in explicit propositions. It simplifies IAM by making the general theories used for inferences (such as a mathematical proof, universal properties etc.) and the belief in their correct application an implicit part of an argumentation event (possibly represented in a text). CRMinf is also less formal than IAM with respect to inference chains (i.e., using conclusions as premises for the next inference) of different granularity. As in IAM, a documented chain of inferences represents a state of knowledge at a point in time, and *not* the historical order of finding its elements. The latter is given explicitly by the time of argument making, which is taken to be a historical fact.

CRMinf makes a basic distinction between three kinds of sources of knowledge because of the way it can be acquired, justified or falsified. These are (1) observation, (2) belief adoption and (3) inference making.

Observation results in knowledge acquired by human senses or by technical devices at a particular place and time. Verification or falsification may re-examine the same environment or things, if sufficiently unaltered, examine observation protocols and the functionality of employed devices and compare with independent observations. Observation is the ultimate primary source of such historical scientific knowledge. The complexity of observation processes, in particular with calibrated means, lies outside the scope of CRMinf, which is primarily concerned with the origin and further history of the observation results, thus providing a common generalization for other CRM extensions, notably CRMsci. In particular, the generic class for observation itself is declared as "S27 Observation" in CRMsci, making use of all constructs of CRMinf for argument making in general, and the class I11 Situation defined in CRMinf.

Belief adoption is used in CRMinf as a term for the use of information someone has heard, read or seen, presented in symbolic form and accepts as their own knowledge. It is the major source of all our communicated knowledge, including reports from observations. It is supported or questioned by assessing the provenance of the source and trust in its credibility. In case of inconsistencies between reported facts, a trust argument may be used to decide on the one or the other. Therefore, CRMinf has developed the concept of Belief Adoption into much more detail than IAM, and created an "articulation" (ontological connection) to the deciphering and reading of original texts addressed by the CRM extension *CRMtex*, in order to be able to represent critical methods in historical research. Subsequent activities of belief adoption form endless networks of information transfer, which are of great importance for historical research.

Inference making, the third kind of acquiring knowledge, means that one concludes from the belief in the truth or likelihood of one or more propositions, the premises, that other propositions are true or likely, using background theories, such as common logic, laws of nature or assumptions about general human behaviour. The peculiarity of this knowledge is that it is relative to the truth of the premise. Therefore, it may be verified or falsified by revising the truth of the premises and the validity of the background assumptions for the given context and the correct application of the background theory, such as the common errors in applying logic. Note that an inference may conclude that at least one of the premises must be wrong. In IAM it is described as "recursive inference", but for reasons of simplicity not distinguished in CRMinf.

The knowledge itself is represented by an instance of I2 Belief, which relates an E39 Actor to a set of propositions (I4 Proposition Set) believed forming one context and holding the same truth value (I6 Belief Value) as explicitly stated by the Actor. It comes into existence as the conclusion of an instance of I1 Argumentation (through one of its sub-classes, S27 Observation, I5 Inference Making, or I7 Belief Adoption), and ends with any modification of its truth value or propositions. Only one E39 Actor may hold a particular instance of I2 Belief, though the E39 Actor may, of course, be an instance of E74 Group. Such an instance of E74 Group may lose or gain members (via one or more instances of E85 Joining or E86 Leaving) without affecting the belief the group representatively maintains. The members supporting the common belief may not necessarily be individually convinced of it. This does not invalidate the (explicitly stated) belief of the Group as expressed, for instance, in a joint publication.

A classical definition of knowledge is that someone believes and can justify it, and it is true. Since to be actually true would require an absolute authority, documented knowledge by CRMinf constructs is regarded as something someone believes (I2 Belief) and can justify – by experience, inference or justified trust in the source. Therefore, a documented belief value, i.e., instance of I6 Belief Value, such as "TRUE", does neither mean that a set of propositions is globally true in the sense of logic, nor that the documenting user believes that they are true. Instead, it means that the documenting user believes that the actor, documented for the respective belief expressed, in its turn, in some explicit form, takes certain propositions to be true "to the best of their knowledge", as is the common scholarly assumption for all scientific publications. This sense of truth corresponds to "inference to the best explanation (IBE)" (Ladyman, 2002) and does not exclude revision when better evidence arrives. In cases where the underlying honesty of expressions by some actors cannot be assumed, it is recommended to document their statements more generally as products of E65 Creation, which applies to all propositions, and not as instances of I2 Belief. Otherwise, using CRMinf for documenting the progress of a serious scientific discourse would be compromised. Notwithstanding, opinions about specific propositional content can analytically be documented by instances of I16 Meaning Comprehension and I7 Belief Adoption. However, documentation would equally be compromised by an unreflected global questioning of trustworthiness of any source, whereas occasional cases of "lies" in generally trusted sources can effectively be dealt with as exceptions when detected and as knowledge revisions by the documentalist about the source. In general, it is recommended to use a richer vocabulary of belief values, at least including "UNKNOWN". CRMinf does not further prescribe such a vocabulary.

If scientists and scholars, and in particular curators, documented the provenance of the immediate sources for each information source in publicly accessible systems, this partial knowledge of provenance could be "stitched together" to more and more complete networks of provenance, similar to the way these days citations in scientific publications are processed. This is one major motivation for CRMinf; the other is to make transparent

how knowledge was acquired for enabling the justification of future revisions, and for documenting who is supporting contested propositions.

Status

CRMinf uses and extends the CIDOC CRM (ISO 21127) as a general ontology of human activity, things and events happening in space-time. It uses the same encoding-neutral formalism of knowledge representation (“data model” in the sense of computer science) as the CIDOC CRM, which can be implemented in RDFS, OWL, on RDBMS and other forms of encoding. Since the model reuses, whenever appropriate, parts of CIDOC CRM, we provide in this document also a comprehensive list of all constructs used from ISO 201127:2023 following the version 7.1.2 maintained by CIDOC.

CRMinf has so far been validated in the British Museum, and by the European-funded project RICOTRANS. This document describes the first consolidated version from this experience and was reviewed by CRM SIG.

Naming Conventions

All the classes declared were given both a name and an identifier constructed according to the conventions used in the CIDOC CRM model. For classes, the identifier consists of the letter I, followed by a number. Resulting properties were also given a name and an identifier, constructed according to the same conventions. The identifier consists of the letter J, followed by a number, which, in turn, is followed by the letter ‘I” every time the property is mentioned “backwards”, i.e., from target to domain. “I” and “J” do not have any other meaning. They correspond respectively to letters “E” and “P” in the CIDOC CRM naming conventions, where “E” originally meant “entity” (although the CIDOC CRM “entities” are now consistently called “classes”), and “P” means “property”.

Whenever CIDOC CRM classes are used in our model, they are named by the name they have in the CIDOC CRM itself.

CRMinf classes and properties hierarchies

The CIDOC CRM model declares no “attributes” at all (except implicitly in its “scope notes for classes), but regards any information element as a “property” (or “relationship”) between two classes. The semantics are, therefore, rendered as properties, according to the same principles as the CDOC CRM model.

Although they do not provide comprehensive definitions, compact monohierarchic presentations of the class and property IsA hierarchies have been found to significantly aid in the comprehension and navigation of the model, and are therefore provided below.

The class hierarchy presented below has the following format:

- Each line begins with a unique class identifier, consisting of a number preceded by the letter “I”, “S”, or “E”.
- A series of hyphens (“-”) follows the unique class identifier, indicating the hierarchical position of the class in the IsA hierarchy.
- The English name of the class appears to the right of the hyphens.
- The index is ordered by hierarchical level, in a “depth first” manner, from the smaller to the larger subhierarchies.
- Classes that appear in more than one position in the class hierarchy as a result of multiple inheritance are shown in an *italic* typeface.

The property hierarchy presented below has the following format:

- Each line begins with a unique property identifier, consisting of a number preceded by the letter “I”, or “P”.
- A series of hyphens (“-”) follows the unique property identifier, indicating the hierarchical position of the property in the IsA hierarchy.
- The English name of the property appears to the right of the hyphens.
- The domain class for which the property is declared.
- The range class of the property.

CRMinf class hierarchy, aligned with portions from the CRMsci and the CIDOC-CRM class hierarchies

This class hierarchy lists:

- all classes declared in CRMinf version 1.2.1,
- all classes declared in CRMsci version 3.0 and CIDOC-CRM version 7.1.3 that are declared as superclasses of classes declared in CRMinf version 1.2.1,
- all classes declared in CIDOC-CRM version 7.1.3 that are either domain or range for a property declared in CRMinf version 1.2,
- all classes declared in CIDOC-CRM version 7.1.3 that are either domain or range for a property declared in CRMinf version 1.2.1,
- all classes declared in CIDOC-CRM version 7.1.3 that are either domain or range for a property that is part of a complete path of which a property declared in CRMinf version 1.2.1 is declared to be a shortcut.

Table 1: Class Hierarchy

E1 CRM Entity
— E2 Temporal Entity
— — E4 Period
— — — E5 Event
— — — — E7 Activity
— — — — — I1 Argumentation
— — — — — — I5 Inference Making
— — — — — — I7 Belief Adoption
— — — — — — I15 Provenance Assessment
— — — — — — S27 Observation
— — — — — — E13 Attribute Assignment
— I2 Belief
— — I12 Adopted Belief
— — I13 Intended Meaning Belief
— — I14 Provenance Belief
— E77 Persistent Item
— — E70 Thing
— — — E71 Human-Made Thing
— — — E28 Conceptual Object
— — — — E89 Propositional Object
— — — — — E73 Information Object
— — — — — — I4 Proposition Set
— — — — — — — I10 Provenance Statement
— — — — — — — I11 Situation

— — — — — — — — S28 Observable Proposition
— — — — — — — I17 One-Proposition Set
— — — — — — I3 Inference Logic
— — — — E90 Symbolic Object
— — — — — *E73 Information Object*
— — — E72 Legal Object
— — — — E90 *Symbolic Object*
— — — — — *E73 Information Object*
— E59 Primitive Value
— — I6 Belief Value

List of external classes used in CRMinf

Table 2: List of external classes grouped by model and ordered by model (exception: CRMbase always goes first) and then by class identifier.

Class identifier	Class name	Model	Version
E1	CRM Entity	CIDOC CRM	7.1.3
E2	Temporal Entity	CIDOC CRM	7.1.3
E4	Period	CIDOC CRM	7.1.3
E5	Event	CIDOC CRM	7.1.3
E7	Activity	CIDOC CRM	7.1.3
E13	Attribute Assignment	CIDOC CRM	7.1.3
E28	Conceptual Object	CIDOC CRM	7.1.3
E59	Primitive Value	CIDOC CRM	7.1.3
E70	Thing	CIDOC CRM	7.1.3
E71	Human-Made Thing	CIDOC CRM	7.1.3
E72	Legal Object	CIDOC CRM	7.1.3
E73	Information Object	CIDOC CRM	7.1.3
E77	Persistent Item	CIDOC CRM	7.1.3
E89	Propositional Object	CIDOC CRM	7.1.3
E90	Symbolic Object	CIDOC CRM	7.1.3
S27	Observation	CRMsci	3.0
S28	Observable Situation	CRMsci	3.0

CRMinf property hierarchy, aligned with portions from the CIDOC-CRM property hierarchies

This property hierarchy lists:

- all properties declared in CRMinf version 1.2.1,
- all properties declared in CIDOC-CRM version 7.1.3 that are declared as superproperties of properties declared in CRMinf version 1.2.1,
- all properties declared in CIDOC-CRM version 7.1.3 that are part of a complete path of which a property declared in CRMinf version 1.2.1, is declared to be a shortcut.
- all properties declared in CIDOC-CRM version 7.1.3 that shortcut a complete path declared in CRMinf version 1.2.1.

Table 3: Property Hierarchy

Property id	Property Name	Entity – Domain	Entity - Range
J4	that (is subject of)	I2 Belief	I4 Proposition Set
J16	- assumed meaning (is assumed meaning in)	I13 Intended Meaning Belief	I4 Proposition Set
J19	- that (is subject of)	I14 Provenance Belief	I10 Provenance Statement
J5	holds to be	I2 Belief	I6 Belief Value
J14	adopted interpretation of (has adopted interpretation)	I12 Adopted Belief	E73 Information Object
J17	about (has interpretation)	I13 Intended Meaning Belief	E73 Information Object
J24	held at least for (is at least validity of)	I11 Situation	E52 Time-Span
J25	is encoded by	I4 Proposition Set	E62 String
J27	that the formal meaning of (has a meaning belief)	I2 Belief	E73 Information Object
J33	assigned proposition (is assigned by)	E13 Attribute Assignment	I17 One-Proposition Set
P15	was influenced (influenced)	E7 Activity	E1 CRM Entity
P17	- was motivated by (motivated)	E7 Activity	E1 CRM Entity
J1	- - used as premise (was premise for)	I5 Inference Making	I2 Belief
J18	- assumed provenance (was assumed by)	I7 Belief Adoption	I14 Provenance Belief
P16	- used specific object (was used for)	E7 Activity	E70 Thing
J3	- - applied (was applied by)	I5 Inference Making	I3 Inference Logic
J7	- - is based on evidence from (is evidence for)	I7 Belief Adoption	E73 Information Object
J22	- - interpreted meaning (was interpreted by)	I16 Meaning Comprehension	E73 Information Object
P173	starts before or with the end of (ends after or with the start of)	E2 Temporal Entity	E2 Temporal Entity
P174	- starts before the end of (ends after the	E2 Temporal Entity	E2 Temporal Entity

	start of)		
P175	- - starts before or with the start of (starts after or with the start of)	E2 Temporal Entity	E2 Temporal Entity
J2	- - - concluded that (was concluded by)	I1 Argumentation	I2 Belief
J13	- - - - adopted interpretation (was concluded by)	I7 Belief Adoption	I12 Adopted Belief
J15	- - - - assumed meaning (was assumed by)	I7 Belief Adoption	I13 Intended Meaning Belief
J21	- - - - concluded provenance of (was assessed by)	I15 Provenance Assessment	I14 Provenance Belief
J23	- - - - interpreted meaning as (was interpretation by)	I16 Meaning Comprehension	I13 Intended Meaning Belief
P173i	ends after or with the start of (starts before or with the end of)	E2 Temporal Entity	E2 Temporal Entity
P174i	- ends after the start of (starts before the end of)	E2 Temporal Entity	E2 Temporal Entity
P175i	- - starts after or with the start of (starts before or with the start of)	E2 Temporal Entity	E2 Temporal Entity
J2i	*- - - was concluded by (concluded that)*	*I2 Belief*	*I1 Argumentation*
J13i	*- - - - was concluded by (adopted interpretation)*	*I12 Adopted Belief*	*I7 Belief Adoption*
J15i	*- - - - was assumed by (assumed meaning)*	I13 Intended Meaning Belief	I7 Belief Adoption
J21i	*- - - - was assessed by (concluded provenance)*	*I14 Provenance Belief*	*I15 Provenance Assessment*
J23i	*- - - - was interpretation by (interpreted meaning)*	*I13 Intended Meaning Belief*	*I16 Meaning Comprehension*
P173	*starts before or with the end of (ends after or with the start of)*	*E2 Temporal Entity*	*E2 Temporal Entity*
P174	*- starts before the end of (ends after the start of)*	*E2 Temporal Entity*	*E2 Temporal Entity*
P184	- - ends before or with the end of (ends with or after the end of)	E2 Temporal Entity	E2 Temporal Entity
P185	- - ends before the end of (ends after the end of)	E2 Temporal Entity	E2 Temporal Entity
J2	*- - - concluded that (was concluded by)*	*I1 Argumentation*	*I2 Belief*
J13	*- - - - adopted interpretation (was concluded by)*	*I7 Belief Adoption*	*I12 Adopted Belief*
J15	*- - - - assumed meaning (was assumed by)*	*I7 Belief Adoption*	*I13 Intended Meaning Belief*
J21	*- - - - concluded provenance of (was assessed by)*	*I15 Provenance Assessment*	*I14 Provenance Belief*
J23	*- - - - interpreted meaning as (was interpretation by)*	*I16 Meaning Comprehension*	*I13 Intended Meaning Belief*
P67	refers to (is referred to by)	E89 Propositional Object	E1 CRM Entity
J28	- contains entity reference (is referred to in)	I4 Proposition Set	E1 CRM Entity
J20	- - is about the provenance of (has provenance claim)	I10 Provenance Statement	E70 Thing

J30	- - has domain (is domain of)	I17 One-Proposition Set	E1 CRM Entity
J31	- - has range (is range of)	I17 One-Proposition Set	E1 CRM Entity
P129	- is about (is subject of)	E89 Propositional Object	E1 CRM Entity
J20	*- - is about the provenance of (has provenance claim)*	*I10 Provenance Statement*	*E70 Thing*
J26i	- - describes the formal meaning of (has unambiguous description)	E73 Information Object	I4 Proposition Set
J29	- contains property type (is property type in)	I4 Proposition Set	E55 Type
J32	- - has property type (is property type of)	I17 One-Proposition Set	E55 Type

List of external properties used in CRMinf

Table 4: List of external properties grouped by model and ordered by model.

Property identifier	Property name	Model	Version
P16	used specific object (was used for)	CIDOC CRM	7.1.3
P17	was motivated by (motivated)	CIDOC CRM	7.1.3
P173	starts before or with the end of (ends after or with the start of)	CIDOC CRM	7.1.3
P174	starts before the end of (ends after the start of)	CIDOC CRM	7.1.3
P175	starts before or with the start of (starts after or with the start of)	CIDOC CRM	7.1.3
P175i	starts after or with the start of (starts before or with the start of)	CIDOC CRM	7.1.3
P184	ends before or with the end of (ends with or after the end of)	CIDOC CRM	7.1.3
P185	ends before the end of (ends after the end of)	CIDOC CRM	7.1.3
P67	refers to (is referred to by)	CIDOC CRM	7.1.3
P129	is about (is subject of)	CIDOC CRM	7.1.3
P140	assigned attribute to (was attributed by)	CIDOC CRM	7.1.3
P141	assigned (was assigned by)	CIDOC CRM	7.1.3
P177	assigned property type (is type of property assigned)	CIDOC CRM	7.1.3

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Graphical Overview

Class Hierarchy

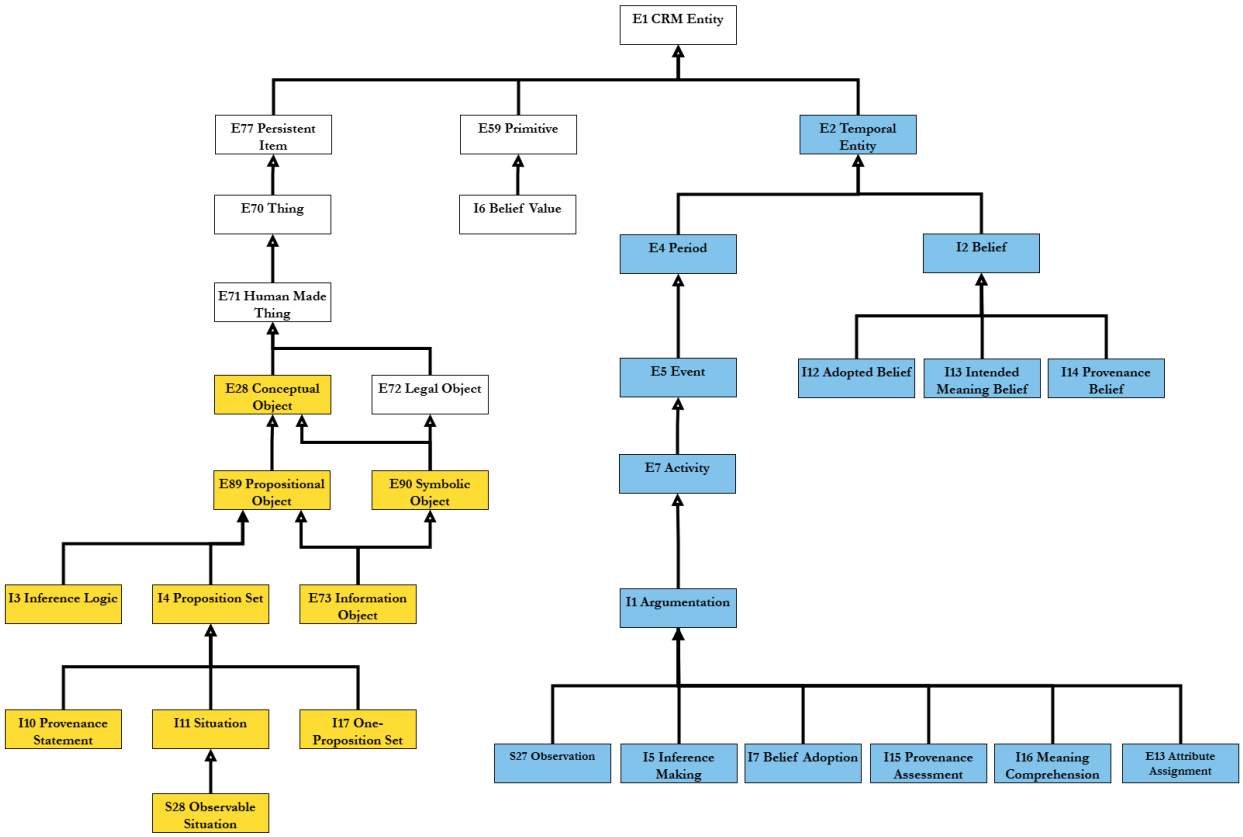

Figure 1: CRMinf Class hierarchy, partially aligned with CIDOC-CRM and CRMsci

Argumentation and Proposition Sets

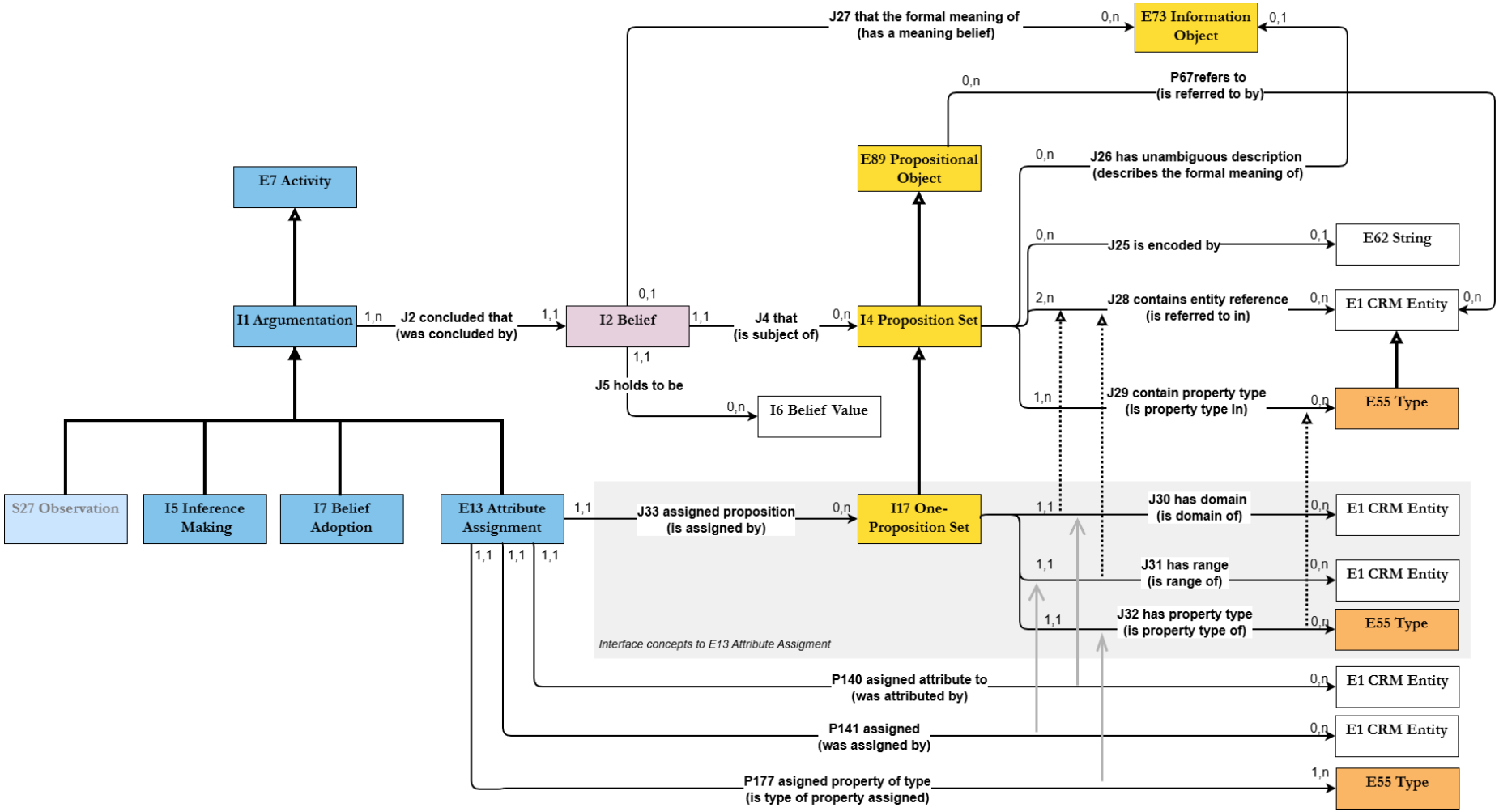

Figure 2: Argumentation, Proposition Sets and E14 Attribute Assignment

The half-saturated colour denotes a concept from CRMsci, its identifier beginning with an “S”.

The only top-level epistemological class in CRMinf is I1 Argumentation, a subclass of E7 Activity. Essentially, it comprises all kinds of activities stating a "justified belief". Under I1 Argumentation, CRMinf distinguishes among three basic ways whereby knowledge can be obtained, namely I5 Inference Making and I7 Belief Adoption (both analysed in this model), and S27 Observation (analysed in CRMsci, a separate extension, in view of its applied complexity). The result of argumentation is the belief (I2 Belief) in an instance of I4 Proposition Set, subclass of E89 Propositional Object, which contains the set of propositions that the actors who carried out the argumentation believe to hold true as a whole. Any belief is modified by a belief value (I6 Belief Value). The kinds of belief values to be used are not defined in the model, in order not to make restrictions to the subtleties of scholarly convictions, but a minimal recommended practice would be using "TRUE", "FALSE", or "UNKNOWN".

As a subclass of E89 Propositional Object, the identity of an instance of I4 Proposition Set is given by the meaning (i.e., the referents) of its elements. The latter are formal propositions, independent from their encoding, such as XML RDF, RDF Trig. However, the propositions in question need to be encoded in some form (in a Named Graph or via *J25 is encoded by*).

An instance of I2 Belief pertains to all its elements taken together, which is more expressive than referring to each of the propositions it contains, one by one. The set forms a sort of semantic context, which, if negated, does not amount to negating one particular element of the proposition set (i.e., stating it to be false). E.g., if we have two reports that one and the same person at a specified time was at different places, we would disbelieve the set, but not its elements.

In practical applications, it can be very difficult to formulate all the premises and conclusions of an argumentation in proposition sets by using predicate logic language or knowledge representation language, in particular, because ontologies for the relevant predicates are still missing. Assuming that the automated reasoning mechanism of a knowledge base doesn't need to access every single element of a proposition set, adequate natural language formulations can be considered sufficiently unambiguous to document relevant premises or conclusions. Therefore, the model offers two simplifications to document the content of a proposition set:

(1) The property *J26 has unambiguous description (describes the formal meaning of)* allows for associating a proposition set (e.g., via its URI) with an instance of E73 Information Object that may contain a text expressing it, such as "Nero was in Antium when the Great Fire broke out in Rome", instead of using *J25 is encoded by*. In this way, the proposition set can still be linked to other entities.
(2) An even shorter modelling option is provided by the property *J27 that the formal meaning of (has a meaning belief)*, which directly associates an instance of I2 Belief with the instance of E73 Information Object containing the text the belief is about.
When this property is used, the intermediate instance of I4 Proposition Set is not explicitly represented and therefore cannot independently be referenced. It is only implicitly defined by *J27 that the formal meaning of (has a meaning belief)*.

In some applications it can be useful to describe by explicit properties that a proposition set refers to certain entities or property types, particularly if the individual propositions constituting the propositions set are accessed by the automated reasoning mechanism in a knowledge base implementation. These are: *J28 contains entity reference (is referred to in)* and *J29 contains property type (is property type in)*.

The above model has a similar, but much wider, purpose than the class **E13 Attribute Assignment** in the CIDOC CRM. In contrast, the result of an E13 Attribute Assignment is exactly *one* proposition held to be true by those that carried out the assignment. E13 Attribute Assignment is a central concept with enough specializations in the CIDOC CRM and extensions. Therefore, this version of CRMinf defines how E13 Attribute Assignment and its relevant properties constitute a special case of I1 Argumentation, logically compatible with the CIDOC CRM. The structural differences between the models require a few "auxiliary" concepts, to the end that formal querying and reasoning in a knowledge base implementation will return the correct integrated interpretations of data given with both models. Even though one may find different uses for them in the future, these "auxiliary concepts" need not to be instantiated for typical **data entry** and therefore **can be ignored by** end users. The same holds for the following explanations until the end of this section:

The “auxiliary concepts” are:

- I17 One-Proposition Set
- *J30 has domain (is domain of)*
- *J31 has range (is range of)*
- *J32 has property type (is property type of)*
- *J33 assigned proposition (is assigned by)*

To this end, I4 Proposition Set is further specialized as I17 One-Proposition Set. I17 One-Proposition Set comes with a set of properties to specialise *J28 contains entity reference (is referred to in)* as *J30 has domain (is domain of)* and *J31 has range (is range of)*, each constrained to exactly one occurrence of E1 CRM Entity. On the other hand, *J32 has property type (is property type of)* specialized *J29 contains property type (is property type in)*, again constraining it to exactly *one* occurrence of E55 Type. As an alternative to using the latter three properties (J30, J31, J32), I17 One-Proposition Set may also be implemented by a reification construct, to which it is regarded as logically equivalent in CRMinf. It may also be used in contexts other than the ones described here.

Further, the property *J33 assigned proposition (is assigned by)* serves for associating an instance of I1 Argumentation with an instance of I17 One-Proposition Set, shortcutting over the intermediate instance of I2 Belief, fixed to an implicit belief value “TRUE”.

With these auxiliary provisions, E13 Attribute Assignment can formally be declared a subclass of I1 Argumentation: The property *P140 assigned property to (was attributed by)* is interpreted as a strong shortcut of the full path *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, *J30 has domain (is domain of)*, to E1 CRM Entity (i.e. this path is an equivalent deduction).

An analogous logical relation holds between (i) *P141 assigned (was assigned by)* and *J31 has range (is range of)*, and (ii) between *P177 assigned property of type (is type of property assigned)* and *J32 has property type (is property type of*), respectively.

Since E13 Attribute Assignment is declared a subclass of I1 Argumentation, it inherits the property *J2 concluded that (was concluded by).* This means that one could instantiate *J2 concluded that (was concluded by)* for an instance of E13 Attribute Assignment directly, in addition to its other properties, which would *violate* its definition in CRMbase. Therefore, the *use* of *J2 concluded that (was concluded by)* by E13 Attribute Assignment is logically **restricted** to being instantiated only via its role as the subproperty *J33 assigned proposition (is assigned by)*. For the interested reader, the complete First Order Logic expressions for the above integration of E13 Attribute Assignment under I1 Argumentation is listed under the property *J33 assigned proposition (is assigned by)*.

Differently put, all triples of properties declared for one class to denote the domain/range and type of another property, such as the properties of E13 Attribute Assignment and its subclasses in CRMbase and extensions, can be interpreted as shortcuts over an implicit instance of I17 One-Proposition Set and its properties *J30 has domain (is domain of), J31 has range (is range of),* and *J32 has property type (is property type of)*, or as a reification pattern implicit in the declaring class.

Observation and Inference Making

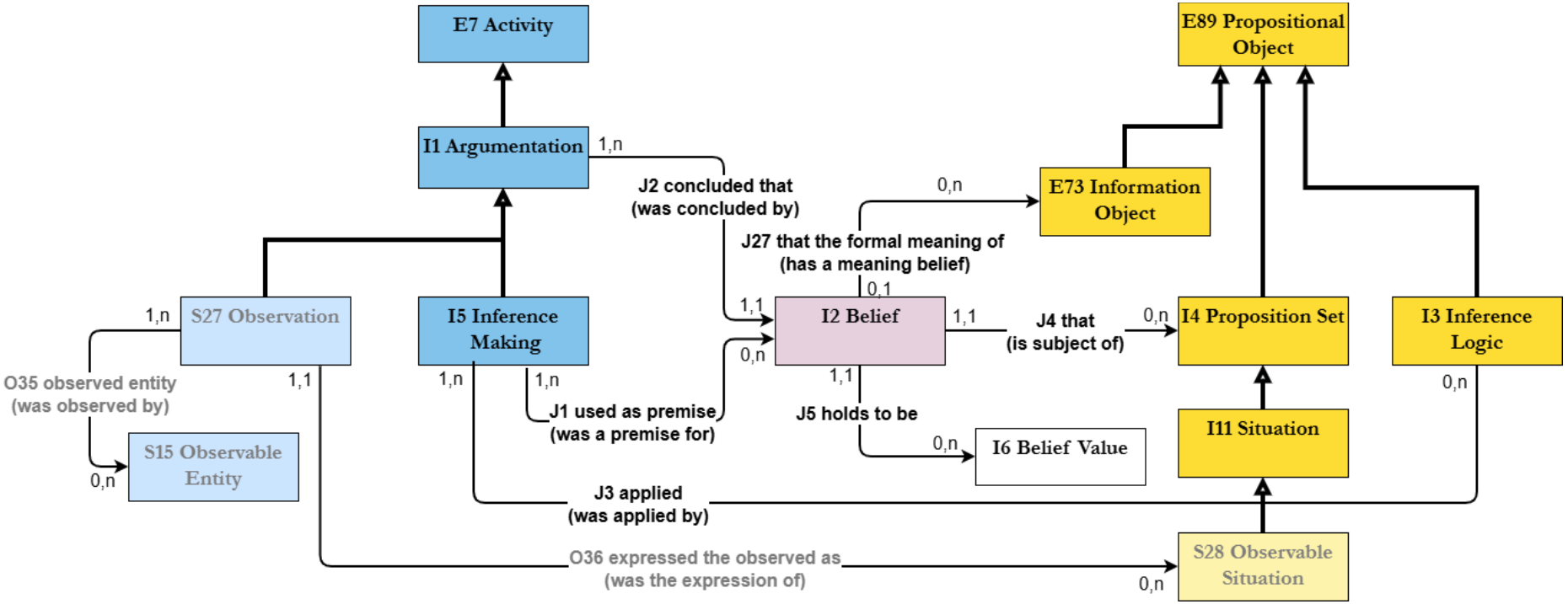

Figure 3: Observation and inference making modelling construct

The half-saturated colours denote concepts from CRMsci, their identifiers beginning with “S” for classes and “O” for properties.

As previously referred to in the Introduction, *Inference making* normally means that one concludes from the belief in the truth or likelihood of one or more propositions, the premises, that other propositions are true or likely, using background theories, such as common logic, laws of nature or assumptions about general human behaviour. This is modelled by the class I5 Inference Making: the belief in the premise, with its set of propositions, is associated via *J1 used as premise (was a premise for),* whereas that in the conclusion is associated using *J2 concluded that (was concluded by)*. The concluded knowledge is contingent upon the assumption that its premises are true. However, an inference may even conclude that at least one of the premises must be wrong, and consequently replaces the belief of the respective Actor in these premises by one to be false or at least "unknown" from this time on.

Making an inference relies on numerous background theories and contextual knowledge, in particular the "Inference for the Best Explanation" (Ladyman, 2002). Hence, for practical reasons, only the least self-evident and most case specific background theories can and should be documented as instances of I3 Inference Logic via *J3 applied (was applied by)*, such as "using the skeletal phenotype characteristics for making a gender estimation".

As described in the introduction, observation is the ultimate primary source of historical scientific knowledge. Due to the complexity of observation processes, they are modelled in detail in CRMsci. Nevertheless, they are completely integrated under the CRMinf concepts: S27 Observation is a subclass of I1 Argumentation, and in the most general case, its results can be described via *J2 concluded that (was concluded by)* and following concepts expressing beliefs, giving credit to the fact that even observations may be unsecure and error prone themselves. Furthermore, CRMsci provides detailed specializations and convenient shortcuts for expressing results, in particular for calibrated measurements, and CRM compatible simplifications falling under the "E13 Argumentation pattern".

In any case, the object of an observation is always regarded to be an instance of a kind of S15 Observable Entity, and the most generic kind of result is regarded to be an instance of S28 Observable Situation (subclass of I11 Situation), which can directly be associated with S27 Observation as domain via the shortcut *O36 expressed the observed as (was the expression of),* if the belief of the observers in the result is "TRUE".

The act of abstraction necessary for expressing the results of an observation as an information object of whatever kind is typically closely tied to an inference, for instance answering the question for which a chemical analysis of some pigments or of C14 content was made, which should not be confused with the (concluded) primary data of the observation.

Belief Adoption Concepts

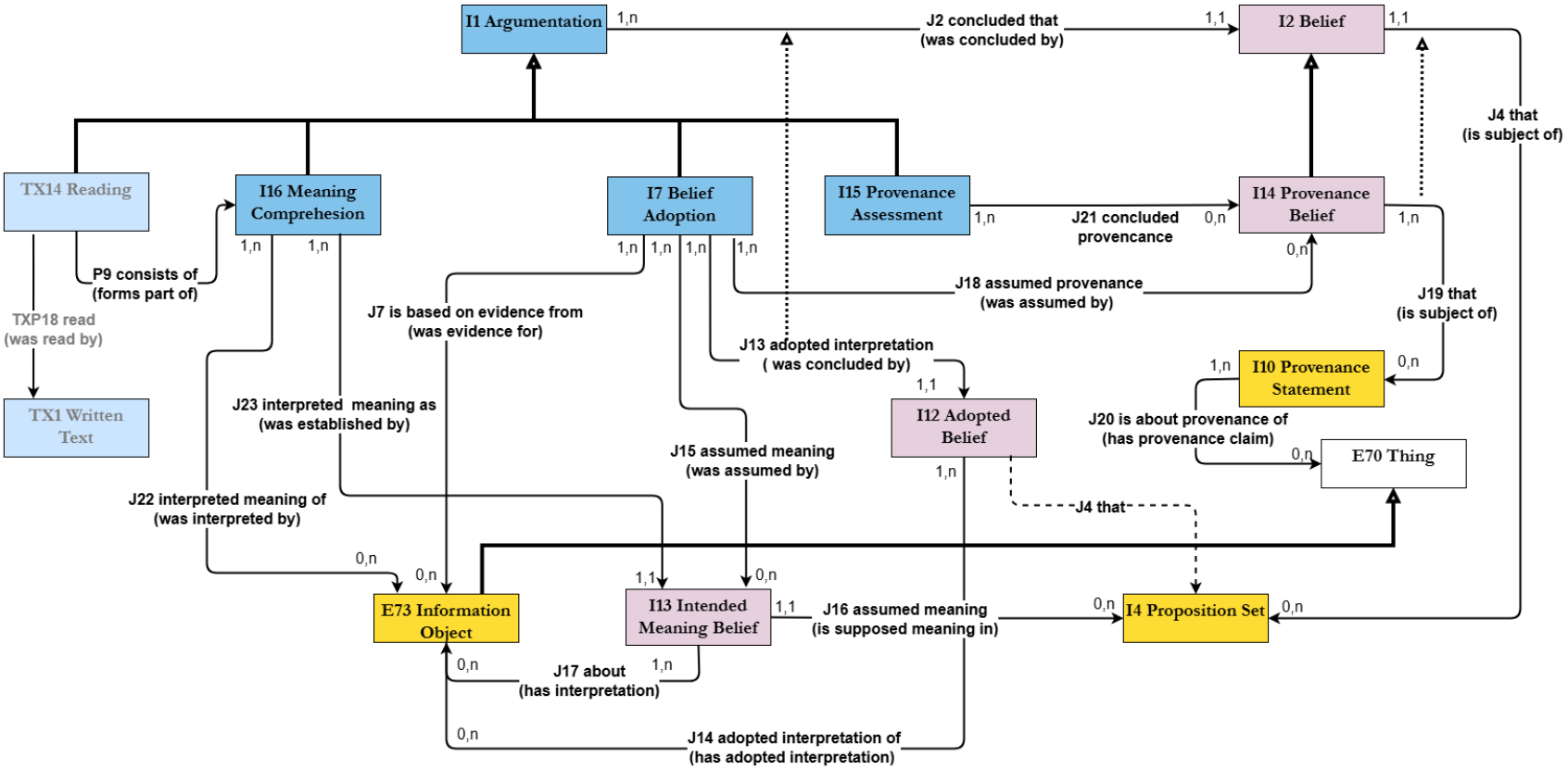

Figure 4:Belief Adoption modelling constructs

The half-saturated colours denote concepts from CRMtex, their identifiers beginning with “TX” for classes and “TXP” for properties.

As mentioned in the Introduction, *Belief adoption* is used in CRMinf as a term for the use of information someone has heard, read or seen presented in symbolic form and has accepted as their own knowledge. It is by far the most frequent way of acquiring knowledge. In many cases, it is equivalent to a citation and reference to a source in an academic publication. However, this model distinguishes a sequence of more detailed prerequisites until one has appropriated some knowledge and refers to it, that may be of great scholarly importance in their own right.

Oral tradition being not yet modelled, the respective processes may start with the "reading" of a material embodiment of a text (or graphics), as modelled in CRMtex by the class TX14 Reading and the property *TXP18 read (was read by)* that associates it with TX1 Written Text, which denotes a material embodiment of a text. CRMtex models in detail the deciphering by material observation and documentation of the result in modern symbolic form as part of the reading.

The actual CRMinf model begins with an instance of I16 Meaning Comprehension, a kind of Argumentation, that *J22 interpreted meaning of (was interpreted by)* an E73 Information Object, which may represent the content of a deciphered text, if a kind of propositional meaning could be established in it. The conclusion, associated by *J23 interpreted meaning as (was interpretation by)* via an I13 Intended Meaning Belief and *J15 assumed meaning (was assumed by)* with an I4 Proposition Set, constitutes an Actor's conviction about what the author of the source, that is, the author of the Information Object, wanted to express, without implying an opinion about its truth. This step is typically implicit in any reading process, including listening to audio, making citations, etc., but it may quite well appear in its own right in critical editions and other scholarly or even jurisdictional investigations.

Once the corresponding source is understood and if it may be regarded to make statements about reality (in contrast to mathematics or fiction), an Actor needs another prerequisite before considering believing one or more statements in it: There must be a trusted provenance of reference of the source. CRMinf models this process, specializing the general pattern of conclusions in I1 Argumentation, by I15 Provenance Assessment, associated by *J21 concluded provenance (was assessed by)* via an I14 Provenance Belief and *J19 that (is subject of)* with an I10 Provenance Statement. The latter, a subclass of I4 Proposition Set, is used to express that the source assessed, a particular instance of E70 Thing and in principle ***available*** to the Actor believing the Provenance Statement, is ***identical*** in the relevant parts or meaning with a thing that was ***present*** in an appropriate event or context of reference of the source in the past. Therefore, the property *J20 is about the provenance of (has provenance claim)* of I10 Provenance Statement, subproperty of *J28 contains entity reference (is referred to in),* restricts the provenance statement to contain at least one proposition about the source the Actor has at hand. There is plenty of literature about the methodology and extreme complexity of actual processes of I15 Provenance Assessment including observations, inferences and other belief adoptions. However, in normal everyday use, provenance statements are typically themselves the object of belief adoption from trusted sources.

Once the respective source is understood and regarded as having a trusted provenance of reference for its content, an Actor may consider whether to trust (or not) in its credibility, believing statements in it, or at least considering them as likely. CRMinf models this process specifically as I7 Belief Adoption. The process stands out against I5 Inference Making and S25 Observation in so far as it is based on arguments of trust, including the human relations with the providers of the source, in particular, but not restricted to, memory institutions. However, the potential immanent complexity of belief adoption is often self-evident, as for a positively used citation. CRMinf meets this challenge with several simplifications, shortcuts for more elaborate reasoning if worth documenting.

In the **most simple** and frequent case, an I7 Belief Adoption is associated via *J7 is based on evidence from (is evidence for)* with an E73 Information Object, the source(s) of the belief will be taken from and by *J13 adopted interpretation (was concluded by)* with an I2 Adopted Belief. The latter inherits from I2 Belief the property *J4 that (is subject of)* for referring to the propositions considered as credible in the source(s) and *J5 holds to be* for expressing the degree of truth the adopting Actor associates with these propositions **in assumed accordance** with the source. So far in CRMinf, any differentiation by an Actor from a degree of belief expressed in a source

is regarded to be a case of I5 Inference Making. Note that a value “TRUE” is meant to characterize a “good explanation” for some facts and not an eternal truth.

The properties *J14 adopted interpretation of (has adopted interpretation)*, *J15 assumed meaning (was assumed by)* and *J17 about (has interpretation)* serve to disambiguate **more complicated** relations between sources and adopted beliefs: *J15 used as premise (was premise for)* associates an I7 Belief Adoption with one or more instances of I13 Intended Meaning Belief that were used to support the I12 Adopted Belief, and possibly were the result of a distinct instance of I16 Meaning Comprehension. In the case that multiple instances of I13 Intended Meaning Belief are used, the property *J17 about (has interpretation)* allows for associating the source for each I13 Intended Meaning Belief separately. Finally, if an instance of I7 Belief Adoption adopts multiple beliefs, the property *J14 adopted interpretation of (has adopted interpretation)* allows for associating an I12 Adopted Belief with its source separately.

Note that subsequent historical activities of belief adoption may form “virtually endless” networks of information transfer, which are of great importance for historical research.

Class and property usage examples

The first running example is about an important archaeological discovery, initially announced in the press, and subsequently in proper scientific archaeological publications (Mandolesi, 2013). It covers two simple events of *observation* (S27 Observation), a simple example of an *inference* (I5 Inference Making) based on a legitimate plausibility argument, and a rare published example of *knowledge revision* (I5 Inference Making) by the same author.

The skeleton found on the left bench of Tomb 6423, nicknamed Tomba dell'Aryballos sospeso, in the Doganaccia necropolis of the Etruscan city of Tarquinia, Tuscany, by Alessandro Mandolesi on the 21th of September 2013, was initially estimated by Mandolesi to be the remains of a male person, due to the spear found next to it, and was published in the press as such. Soon after, osteological analysis carried out by the team revealed that it belonged to a female person, as published in the official academic papers afterwards. This is a good example for a simple inference and scientific knowledge revision. We refer to this skeleton in the examples found throughout the text as "The skeleton on the left bench in La Tomba dell'Aryballos sospeso", and to the burial arrangement as "The burial arrangement on the left bench in La Tomba dell'Aryballos sospeso", respectively.

We continue this example further: Critical to this example is the archaeological context. When opening the tomb, Mandolesi observed that it had been untouched since the time of the last burial it contained, a very rare fact. Therefore, the arrangement found was interpreted to be the one intended by the people who had carried out the burial.

The interpretation of this example in terms of formal propositions is graphically shown in Figure 4, below; it can also be found in the examples for individual concepts throughout the class and property declarations.

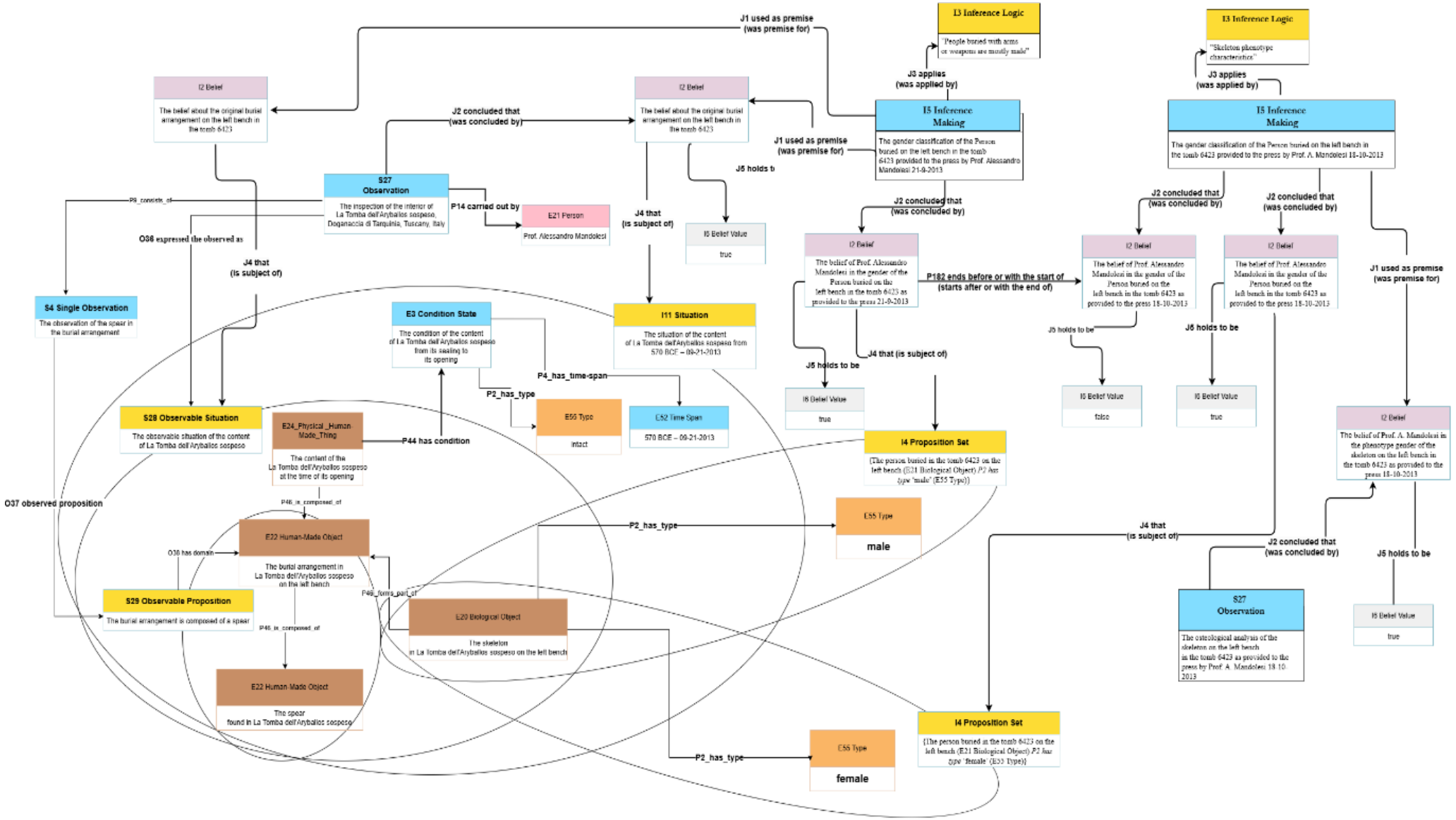

Figure 5: La Tomba dell'Aryballos sospeso; a case of knowledge revision

The second running example is the blog post by Francesca Bologna concerning Nero, and, in particular, his whereabouts during the Great Fire of Rome (Bologna, 2021). It demonstrates a case of understanding and citing two contradictory historical sources (I10 Provenance Statement), without explicitly believing them (I13 Intended Meaning Belief). Bologna proceeds with making a scholarly argument for trusting the one (I7 Belief Adoption) over the other, which she disbelieves (I5 Inference Making). The argument she makes is based on plausibility, the provenance of the information that the author of each source had, and an assumed bias on the part of one of the sources, which she contextually justifies.

Here are the relevant citations from Bologna (2021):

On 19 July AD 64, a fire started close to the Circus Maximus. The flames soon encompassed the entire city of Rome and the fire raged for nine days. Only four of the fourteen districts of the capital were spared, while three were completely destroyed.

Later historians blamed Nero for the event, claiming that he set the capital ablaze in order to clear land for the construction of a vast new palace. According to Suetonius and Cassius Dio, Nero took in the view of the burning city from the imperial residence while playing the lyre and singing about the fall of Troy. This story, however, is fictional.

Most of what we know about Nero comes from the surviving works of three historians –Tacitus, Suetonius, and Cassius Dio. All written decades after Nero's death, their accounts have long shaped our understanding of this emperor's rule. However, far from being impartial narrators presenting objective accounts of past events, these authors and their sources wrote with a very clear agenda in mind. Nero's demise brought forward a period of chaos and civil war –one that ended only when a new dynasty seized power, the Flavians. Authors writing under the Flavians had all an interest in legitimizing the new ruling family by portraying the Julio-Claudians in the worst possible light, turning history into propaganda. These accounts became the 'historical' sources used by later historians, therefore perpetuating a fabricated image of Nero, which has survived all the way to the present.

The interpretation of this example in terms of formal propositions is graphically shown in Figure 5, below; it can also be found in the examples for individual concepts throughout the class and property declarations.

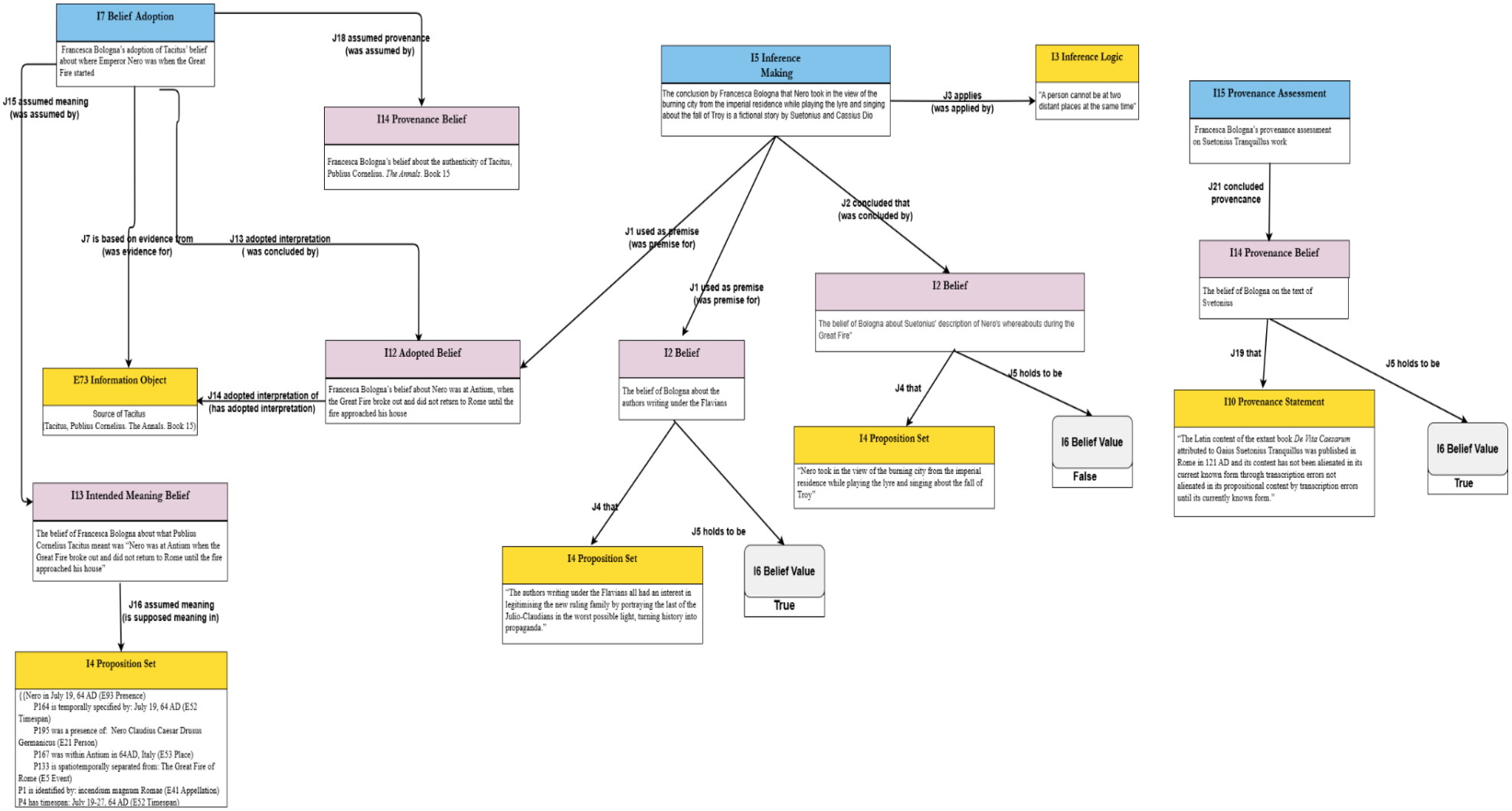

Figure 6: A scholarly argument concerning Nero's whereabouts during the Great Fire of Rome

CRMinf Class Declarations

The classes are comprehensively declared in this section using the following format:

- Class names are presented as headings in boldface, preceded by the unique identifier of the class;
- The line “Subclass of:” declares the superclass of the class from which it inherits properties;
- The line “Superclass of:” is a cross-reference to the subclasses of the class;
- The line “Scope note:” contains the textual definition of the concept the class represents;
- The line “Examples:” contains a bulleted list of examples of instances of this class;
- The line “In first-order logic:” expresses the formal constraints of the class in terms of logical axioms in a First-Order Logic notation.
- The line “Properties:” declares the list of the properties for the class in question;
- Each property is represented by its unique identifier, its forward name, and the range class that it links to, separated by colons;
- Inherited properties are not represented;
- Properties of properties, if they exist, are provided indented and in parentheses beneath their respective domain property

I1 Argumentation

Subclass of:

E7 Activity

Superclass of:

I5 Inference Making
I7 Belief Adoption
I15 Provenance Assessment
I16 Meaning Comprehension
E13 Attribute Assignment
S27 Observation

Scope note:

This class comprises the activity of making honest inferences or observations. An honest inference or observation is one, in which the E39 Actor carrying out the I1 Argumentation justifies and believes that the I6 Belief Value associated with the resulting I2 Belief about the I4 Proposition Set is the correct value at the time that the activity was undertaken and that any I3 Inference Logic or methodology was correctly applied.

An instance of E39 Actor may carry out an instance of I1 Argumentation, though the E39 Actor may, of course, be an instance of E74 Group.

Examples:

- My classification and dating of this bowl (I5) (fictitious)
- My adoption of the belief that Dragendorff type 29 bowls are from the 1st Century AD (I7) (fictitious)
- The gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso provided to the press by Prof. Alessandro Mandolesi on the 21st September 2013 (E17, I5) (Squires, 2013)
- Francesca Bologna's adoption of Tacitus' belief concerning Emperor Nero's whereabouts at the beginning of the Great Fire of Rome (I7) (Bologna, 2021) [Francesca Bologna adopted the belief of Tacitus, on the grounds that he was the only historian alive at the time of the Great Fire of Rome, although he was only 8 years old at the time). According to Tacitus: "Nero at this time was at Antium and did not return to Rome until the fire approached his house." In Tacitus, Publius Cornelius. *The Annals*. Book 15 [15.16].]

In First Order Logic:

$I1(x) \Rightarrow E7(x)$

Properties:

J2 concluded that (was concluded by): I2 Belief

I2 Belief

Subclass of:

E2 Temporal Entity

Superclass of:

I12 Adopted Belief
I13 Intended Meaning Belief
I14 Provenance Belief

Scope note:

This class comprises the notion that the associated I4 Proposition Set is to have a particular I6 Belief Value by a particular E39 Actor. This can be understood as the period of time that an individual group holds a particular set of propositions to be true, false, or somewhere in between.

Examples:

- Ian Hodder's belief from 1996 on, that Floor B was earlier than wall C of building 1 in the north area of Catalhöyük (Hodder, 1999)
- One spear being at the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso following Alessandro Mandolesi's observation (I2) (Squires, 2013) (Mandolesi, 2013)
  [An observed fact, be it by many people, still constitutes a belief in the most general sense.]
- The belief of Alessandro Mandolesi in the gender of the skeleton on the left bench in La Tomba dell'Aryballos sospeso, as provided to the press on the 21st September 2013 (I2) (Squires, 2013)

In First Order Logic:

$I2(x) \Rightarrow E2(x)$

Properties:

J4 that (is subject of): I4 Proposition Set
J5 holds to be: I6 Belief Value
J27 that the formal meaning of (has a meaning belief): E73 Information Object

I3 Inference Logic

Subclass of:

E89 Propositional Object

Superclass of:

Scope note:

This class comprises the rules used as inputs to I5 Inference Making.

In this context, the term "logic" is used in the most general sense of the Greek term, and not in the mathematical sense only. Examples are the direct application of formal logic, mathematical theories, and calculus, formal or informal default reasoning based on default values associated with categories, probabilistic reasoning-based mathematical models and assumed or observed frequencies for certain categories, application of theoretical social models and comparisons with "cultural parallels", etc. An instance of Inference Logic could also be a reference to the exact software release of a Bayesian reasoner, a rule such as "later layers are on top of earlier layers", or even a term like "social intuition", if this is scholarly acceptable (after Doerr, Kritsotaki and Boutsika, 2011).

Indeed, anything that is scientifically or academically acceptable as a method for drawing conclusions may be included, for instance, human pattern recognition.

A particular instance of I3 Inference Logic would be the algorithm implemented in a particular revision of a software package.

Instances of I3 Inference Logic not only comprise the method of reasoning, but also the set of categorical laws or axioms used in the argumentation. Often, both are inextricably interwoven, for instance in a software implementation.

Examples:

- the statement “People buried with arms or weapons are mostly male” [that was used by Mandolesi for a first estimation of the gender of the skeleton found at the left bench in La Tomba dell’Aryballos sospeso (I2), which was subsequently provided to the press on 21st September 2013. (Squires, 2013)]
- the statement “A person cannot be at two distant places at the same time” [that was implicitly applied by Bologna, in adopting the belief that Nero was at Antium, and could not have simultaneously been in Rome, at the time that the Great Fire broke. (Bologna, 2021)]
- using the skeletal phenotype characteristics, such as the expression of the Proturberantia occipitalis externa of a skull, for making a gender estimation (Nagare et al., 2018)

In First Order Logic:

I3(x) ⇒ E89(x)

Properties:

I4 Proposition Set

Subclass of:

E89 Propositional Object

Superclass of:

I10 Provenance Statement
I11 Situation
I17 One-Proposition Set

Scope note:

This class comprises sets of unambiguous propositions that are, or could, in principle, be, encoded in a knowledge representation language. These propositions should be factual, i.e., each proposition should pertain to at least one particular item, in contrast to universals, such as instances of E55 Type. The identity of an instance of I4 Proposition Set is given by the total of its content, regardless of equivalent encodings.

An instance of I4 Proposition Set should be regarded per se to be neutral to its relationship to reality. The relationship to reality is determined by the link using the proposition set:

If an instance of I2 Belief refers to an instance of I4 Proposition Set, the belief value “TRUE” means that the proposition sets are believed to correspond to reality, assuming that the propositions can be related to reality –i.e., are about real-world items, in contrast to mathematical statements, for example. A belief value “FALSE” means that at least one of the propositions in the set is regarded as not corresponding to reality. Belief values expressing possibility or probability will mean “possibly real”, given that the propositions can be related to reality.

Some properties associating an activity with an instance of I4 Proposition Set may imply the belief of the Actor carrying out the activity that the propositions are true. This should be expressed in the respective scope notes.

In a Knowledge Base implementation, an instance of I4 Proposition Set may be represented by the URI of a Named Graph, but only if the propositions are encoded in the data model of the Knowledge Base and held to be true by the maintainers of the Knowledge Base, because they

become part of the stated knowledge. In this case, the platform-internal relation between the URI and its content, is regarded as equivalent to the property *J25 is encoded by*.

Proposition Sets held to be possibly true by the maintainers of a Knowledge Base may also be introduced as Named Graphs, if the operation of the Knowledge Base foresees filtering by provenance and likelihood. In this case, Named Graphs are particularly effective.

Examples:

- the proposition set with content:
  {Nero in July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Timespan)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Antium in 64AD, Italy (E53 Place)
  P133 is spatiotemporally separated from: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  } (Bologna 2021)
  [The Proposition Set above represents Francesca Bologna's adopted belief, according to which Publius Cornelius Tacitus meant that "Nero was at Antium when the Great Fire broke out and did not return to Rome until the fire approached his house"]
- the proposition set with content:
  {Nero July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Timespan)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Rome in 64AD, Italy (E53 Place)
  P10 falls within (contains): Nero Singing (E7 Activity)
  P2 has type: Singing (E55 Type)
  P14 carried out by: Nero Claudius Caesar Drusus Germanicus (E21)
  P4 has timespan: July 19, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  P132 spatiotemporally overlaps with: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  } (Bologna 2021)
  [The Proposition Set above represents Francesca Bologna's intended meaning belief, according to which Gaius Suetonius Tranquillus assumed that Nero was singing in Rome while it was burning from July 19 in 64 AD.]

In First Order Logic:

I4(x) ⇒ E89(x)

Properties:

J25 is encoded by: E62 String
J26 has unambiguous description (describes the formal meaning of): E73 Information Object
J28 contains entity reference (is contained in): E1 CRM Entity
J29 contains property type (is property type in): E55 Type

I5 Inference Making

Subclass of:

I1 Argumentation

Superclass of:

Scope note:

This class comprises the action of making honest propositions and statements about particular states of affairs in reality or possible realities, or categorical descriptions of reality by using inferences from other statements based on hypotheses and any form of formal or informal logic. It includes evaluations, calculations, and interpretations, based on mathematical formulations and propositions.

It is characterized by the use of an existing I2 Belief as the premise that, taken together with a set of I3 Inference Logic, draws a further I2 Belief as a conclusion.

Documenting instances of I5 Inference making primarily enables tracing the dependency of knowledge from conclusion to premise through subsequent inferences possibly back to primary evidence, so that the range of influence of knowledge revision at any intermediate stage of complex inference chains on current convictions can be narrowed down by query. The explicit reference to the applied inference logic further allows scholars and scientists to assess if they can or would follow the documented argument. The class is not intended to promote the use of computationally decidable systems of logic as replacements of scholarly justifications of arguments, even though it allows for documenting the use of decidable logic, if that was deemed adequate for the problem at hand. Principles of scholarly justifications of arguments are also regarded as kinds of inference logic.

Examples:

- the gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso (E17, I5), provided to the press by Alessandro Mandolesi on the 21st September 2013 (Squires, 2013)
- Francesca Bologna concluding that the story, according to which, Nero took in the view of the burning city of Rome from the imperial residence while playing the lyre and singing about the fall of Troy, forms a tale devised by Suetonius and Cassius Dio (Bologna, 2021).

In First Order Logic:

$I5(x) \Rightarrow I1(x)$

Properties:

J1 used as premise (was a premise for): I2 Belief
J3 applies (was applied by): I3 Inference Logic

I6 Belief Value

Subclass of:

E59 Primitive Value

Superclass of:

Scope note:

This class comprises any encoding of the value of the truth of an I2 Belief. It may be expressed in terms of discrete logic, modal logic, probability, fuzziness, or any other adequate representational system.

A minimum requirement of flexibility is for three values: "TRUE"; "FALSE"; "UNKNOWN".

Examples:

- TRUE
- FALSE

In First Order Logic:

I6(x) ⇒ E59(x)

Properties:

I7 Belief Adoption

Subclass of:

I1 Argumentation

Superclass of:

Scope note:

This class comprises the action of an E39 Actor adopting propositions taken from an interpretation of the intended meaning of an instance of E73 Information Object as being true, or in some way likely to be true. The adopted propositions constitute the conclusion of the action in the form of a new instance of I12 Adopted belief of the actor adopting it.

The basis of I7 Belief Adoption is the justification of trust in the source of the adopted propositions, rather than the application of rules for inferring the respective propositions from logical premises.

Typical examples are the citation of academic papers or the reuse of datasets.

Where an instance of I7 Belief Adoption is based on personal communication (marked as *pers.comm.* in the studied text), this should be represented by using P2 has type: *"Pers.Comm"*, directly from the instance of I7 Belief Adoption.

Examples:

- Francesca Bologna adopting the belief of Tacitus concerning Emperor Nero's whereabouts at the beginning of the Great Fire of Rome (I7) (Bologna, 2021). [Francesca Bologna adopted the belief of Tacitus, on the grounds that he was the only historian alive at the time of the Great Fire of Rome, although only 8 years old at the time. According to Tacitus: "Nero at this time was at Antium and did not return to Rome until the fire approached his house." In Tacitus, Publius Cornelius. *The Annals*. Book 15 [15.16].

In First Order Logic:

I7(x) ⇒ I(x)

Properties:

J7 is based on evidence (was evidence for): E73 Information Object
J13 adopted interpretation (was concluded by): I12 Adopted Belief
J15 assumed meaning (was assumed by): I13 Intended Meaning Belief
J18 assumed provenance (was assumed by): I14 Provenance Belief

I10 Provenance Statement

Subclass of:

I4 Proposition Set

Superclass of:

Scope note:

This class comprises statements about the provenance of instances of E70 Thing existing at the time of making the provenance statements. An instance of I10 Provenance Statement must contain propositions about the presence of the respective instances of E70 Thing in an event or spatiotemporal context of reference. Characteristically, it may pertain to the writing by a known author at ta known or unknown date or place, or to the existence of the text known to some public, regardless of the truth of authorship.

In case that only information objects exist describing the proper thing of interest, such as a photo of a lost archaeological object, or a photo of a photo thereof, an instance of I10 Provenance Statement should contain the relevant chain of intermediate events transferring the information from the proper thing of interest up to the extant information objects taken into account, or they, at least, should refer to said chain of intermediate events.

The property *J20 is about the provenance of (has provenance claim)* can be used to link the instance of I10 Provenance Statement as a whole, with the proper thing of interest. It constitutes a constraint to the provenance statement that it must contain the description of the relevant context of reference, and, if applicable, to the relevant chain of intermediate events transferring the information.

Examples:

- the statement: “The copy of Tacitus, Publius Cornelius. The Annals. Book 15 [15.16] that Francesca Bologna obtained from the British Museum in 2021, represents a text written by the ancient Roman historian, Publius Cornelius Tacitus.”
  [This statement can be represented by a set of CRM-compatible propositions]
- the statement: “The Latin content of the extant book *De Vitae Caesarum*, attributed to Gaius Suetonius Tranquillus, was published in Rome 121 AD and its propositional content has not been alienated in its current known form through transcription errors.”
  [This statement can be represented by a set of CRM compatible propositions]
- the statement: “The exemplar of *The Merchant of Venice, Quarto 1* (1600), owned by the British Library, shelf number ‘BL C.34.k.22’, was published in 1600 AD by Thomas Hayes.”
  [This statement can be represented by a set of CRM compatible propositions]
- the statement: “The Nebra Sky Disc dates to the Early Bronze Age.” (Pernicka et al., 2020)

In First Order Logic:

I10(x) ⇒ I4(x)

Properties:

J20 is about the provenance of (has provenance claim): E70 Thing

I11 Situation

Subclass of:

I4 Proposition Set

Superclass of:

S28 Observable Situation

Scope note:

This class comprises sets of formal propositions characterizing a particular state of affairs as having certain relations between particular items or within certain ranges or kinds of related entities, over or within a timespan. The respective characterization is in general not regarded as being complete, but as constituting an aspect of interest of an actor. It may capture an observed aspect of a real situation, such as some known “persons A and B have met”, or be used for a question, such as whether “persons A and B have ever met”, or even for negation, such as “*persons A and B have met* is FALSE”.

Since many kinds of properties in the knowledge representation framework, that the CRM is based on, do not specify times of validity, a particular timespan, further constraining the concerned validity of all referred properties, can optionally be specified using the property *J24 held at least for (is at least validity of)*. The identity of an instance of I11 Situation is given its total content f propositions, regardless of encoding, or the value for the property *J24 held at least for (is at least validity of)*, if used. If an instance of I11 Situation is used to characterize an observation, its temporal validity is necessarily constrained at least to the period of observation.

Examples:

- the persistence of the value of the pH for sample XIV during the period of the pH measurement, which took place one month after the application of Ca(OH)2 dispersion to the sample (Giorgi et al., 2002)
- The situation reported by Shaykh Abu Abdallah (Ibn Battuta) about his visit to Cairo, Egypt, in 1326AD: “As for the Maristan [hospital], which lies "between the two castles" near the mausoleum of Sultan Qala'un, no description is adequate to its beauties. It contains an innumerable quantity of appliances and medicaments, and its daily revenue is put as high as a thousand dinars.”
  [After the translation by H.A.R Gibb 1926 of the travel report by Ibn Battuta, from Tanger, Morocco. The Maristan exists still today, but this is the original report about its operation by an eye witness in the year 1326. The reported revenue came from donations. The treatment was free.] (Gibb 1926, pp. 50-51)
- The situation reported by Shaykh Abu Abdallah (Ibn Battuta) about his visit to China, in 1345-1346 AD: “In every Chinese city there is a quarter for Muslims in which they live by themselves, and in which they have mosques both for the Friday services and for other religious purposes. The Muslims arc honoured and respected.”
  [After the translation by H.A.R Gibb 1926 of the travel report by Ibn Battuta, from Tanger, Morocco. Ibn Battuta visited China, at least the cities of Quanzhou and Hangzhou, in the year 1345-1346] (Gibb 1926, pp. 283)
- The situation reported by Seydi Ali Reis arriving with the remainder of his fleet in Surat, Gujarat, India in 1554AD: Sultan Ahmad Shah III, the 12-year-old new ruler of Gujarat, being at war with the usurper Nasir-ul-Mulk Khan at Burudj. Nasir-ul-Mulk Khan having allied with Portuguese colonies Goa. Melek Essed being commander of Daman, Gujarat, India and Hamza Agha commander of Surat under Sultan Ahmad. The Portuguese being at war with the Ottoman Empire over the control of the Indian Ocean. Sultan Ahmad seeking support by Seydi Ali Reis’ soldiers.
  [Seydi Ali Reis (or Katib-I Rumi) (1498-1563), admiral of Egypt of the Ottoman Empire under Suleiman I was ordered to transfer a fleet of 15 galleys from Basra, Irak, to Egypt, and driven by heavy storms to the coast of Gujarat. In his book “The Mirror of Countries”, 1557, he reported this expedition and his return home by land through Central Asia. This is a short summary from the German translation pp. 173-176 (Diez 1815)]
- The situation reported by Antonio Pigafetta from Magellan’s voyage at 21st of October 1520, about at S 52°24’ W 69°30’: “This strait was a round place surrounded by mountains, as I have said, and the greater number of the sailors thought that there was no place by

which to go out thence to enter into the peaceful sea. But the captain-general said that there was another strait for going out, and said that he knew it well, because he had seen it by a marine chart of the King of Portugal, which map had been made by a great pilot and mariner named Martin of Bohemia". (Pigafetta and Stanley, 1874: 58)
[Antonio Pigafetta was the chronicler of the voyage, one of the survivors. During the expedition, he served as Magellan's assistant until Magellan's death in the Philippine Islands, and kept an accurate journal ('Antonio Pigafetta', 2024).]

- The proposition set with content:
{The content of the La Tomba dell'Aryballos sospeso at the time of its opening (E24 Physical Human-Made Thing) is composed of The burial arrangement in La Tomba dell'Aryballos sospeso on the left bench (E22 Human-Made Object).
The burial arrangement in La Tomba dell'Aryballos sospeso on the left bench (E22 Human-Made Object) is composed of The spear found in La Tomba dell'Aryballos sospeso (E22 Human-Made Object).
The skeleton in La Tomba dell'Aryballos sospeso on the left bench (E20 Biological Object) forms part of The burial arrangement in La Tomba dell'Aryballos sospeso on the left bench (E22 Human-Made Object).
The skeleton in La Tomba dell'Aryballos sospeso on the right bench (E20 Biological Object) forms part of The content of the La Tomba dell'Aryballos sospeso at the time of its opening (E24 Physical Human-Made Thing).
The content of the La Tomba dell'Aryballos sospeso at the time of its opening (E24 Physical Human-Made Thing) has condition The condition of the content of the La Tomba dell'Aryballos sospeso from its sealing to its opening (E3 Condition State).
The condition of the content of the La Tomba dell'Aryballos sospeso from its sealing to its opening (E3 Condition State) has type 'intact' (E55 Type).
The condition of the content of the La Tomba dell'Aryballos sospeso from its sealing to its opening (E3 Condition State) has time-span The time-span of La Tomba dell'Aryballos sospeso from its sealing to its opening (E52 Time-Span).
The time-span of La Tomba dell'Aryballos sospeso from its sealing to its opening (E52 Time-Span) ongoing throughout 570 BCE – 09-21-2013 CE (E61 Time Primitive).
} (I11) (Mandolesi 2013)
[This Situation is the strict result of an observation, except for the duration of the condition of "being intact".]

In First Order Logic:

$I11(x) \Rightarrow I4(x)$

Properties:

J24 held at least for (is at least validity of): E52 Time-Span

I12 Adopted Belief

Subclass of:

I2 Belief

Superclass of:

Scope note:

This class comprises the notion that an instance of E39 Actor adopted the meaning of an associated instance of I4 Proposition Set by arguments of trust from a source created by another instance of E39 Actor, and holds it as being true or in some way likely to be true. This source can be documented via the property *J14 adopted interpretation of (has adopted interpretation)*. The used interpretation of the meaning of the source may be a belief of the

adopting Actor or another one and can be documented as an instance of I13 Intended Meaning Belief, if this detail is relevant.

Examples:

- Francesca Bologna's belief that Nero was at Antium, when the Great Fire broke out and did not return to Rome until the fire approached his house (Bologna, 2021)

In First Order Logic:

I12(x) ⇒ I2(x)

Properties:

J14 adopted interpretation (has adopted interpretation): E73 Information Object

I13 Intended Meaning Belief

Subclass of:

I2 Belief

Superclass of:

Scope note:

This class comprises beliefs on the part of an instance of E39 Actor that a particular I4 Proposition Set formally represents (in part or in its entirety) the intended meaning that was created by another instance of E39 Actor, without considering an opinion yet about its truth or trustworthiness.

The belief constitutes an interpretation of the source. The respective proposition set can be documented using the property *J16 assumed meaning (is supposed meaning in)*, whereas the respective source can be documented via the property *J17 about (has interpretation)* and holds as being true or in some way likely to be true.

Examples:

- Francesca Bologna's belief that Publius Cornelius Tacitus meant that "Nero was at Antium when the Great Fire broke out and did not return to Rome until the fire approached his house." (Bologna, 2021)
- Francesca Bologna's belief that Gaius Suetonius Tranquillus meant that "Nero was singing in Rome while it burned from July 19 in 64 AD." (Bologna, 2021)

In First Order Logic:

I13(x) ⇒ I2(x)

Properties:

J16 assumed meaning (is supposed meaning in): I4 Proposition Set
J17 about (has interpretation): E73 Information Object

I14 Provenance Belief

Subclass of:

I2 Belief

Superclass of:

Scope note:

This class comprises beliefs of an Actor that a particular instance of E70 Thing, in general available to this Actor, is identical to one present in a relevant event or context of reference in the past, such as a text in a book being sufficiently identical to the one in the claimed author's original manuscript or edition, to be used by the Actor for citation. Other examples are the provenance of archaeological objects in collections, which may pertain to the claimed excavation spot or to the inferred context of their creation.

The term "in general available" means that the thing is either physically in the hands of the actor or that the actor or an actor of their trust has, in principle, the ability to get access to the thing. In case that only information objects exist describing the proper thing of interest, such as a photo of a lost archaeological object, an instance of I14 Provenance Belief should be based on arguments including references to provenance beliefs about descriptions, representations and the described things.

A formal description about the assumed provenance can be documented via the property J*19 that (is subject of)*. Note that, depending on the intended argumentation about the respective instance of E70 Thing, different aspects of provenance may be described about the same instance of E70 Thing.

Examples:

- Francesca Bologna's belief about the authenticity of Tacitus, Publius Cornelius. The Annals. Book 15

In First Order Logic:

I14(x) ⇒ I2(x)

Properties:

J19 that (is subject of): I10 Provenance Statement

I15 Provenance Assessment

Subclass of:

I1 Argumentation

Superclass of:

Scope note:

This class comprises activities of making arguments and concluding about the likely provenance of instances of E70 Thing existing at the time of this assessment. These activities may further be about the provenance of things referred to or represented by existing information objects, and subsequent references.

Examples:

- the assessment by Ernst Pernicka et al. about the provenance of the Nebra Sky Disc (Pernicka et al., 2020)

In First Order Logic:

I15(x) ⇒ I1(x)

Properties:

J21 concluded provenance (was assessed by): I4 Provenance Belief

I16 Meaning Comprehension

Subclass of:

I1 Argumentation

Superclass of:

Scope note:

This class comprises processes of interpreting the intended meaning of parts or the whole of the content of an instance of E73 Information Object as propositions. Such interpretations may include the disambiguation of the meaning of words and expressions, expanding abbreviations, resolving named entities, references and co-references, and completing missing text parts, without however arguing about the actual truth of the information.

In principle, any use of an information object pertaining to its meaning implies an instance of I16 Meaning Comprehension. However, in practical applications, texts in natural language are often clear enough, so that no explicit explanation of the interpretation is needed for the user. In such cases, there is no need to create explicit instances of I16 Meaning Comprehension, but the adopted belief may directly be linked via *J26 adopted interpretation (has adopted interpretation)*, or the instance of I16 Meaning Comprehension may be made implicit to an instance of I7 Belief Adoption by multiple instantiation.

Explicitly documenting instances of I16 Meaning Comprehension can be very useful, especially when the interpretations are not obvious or if there exist competing arguments about them.

Examples:

- My understanding of the statements found in the book *De Vita Caesarum*, by Gaius Suetonius Tranquillus, concerning Emperor Nero's whereabouts in Rome during the Great Fire of Rome, from 19th July 64 AD and on ('The Twelve Ceasars', 2024)

In First Order Logic:

$I16(x) \Rightarrow I1(x)$

Properties:

J22 interpreted meaning of (was interpreted by): E73 Information Object
J23 interpreted meaning as (was interpretation by): I13 Intended Meaning Belief

I17 One-Proposition Set

Subclass of:

I4 Proposition Set

Superclass of:

Scope note:

This class comprises proposition sets containing exactly one proposition representing a binary relationship, which is, or could, in principle, be, encoded in a knowledge representation language. The identity of an instance of I17 One-Proposition Set is given by its entire content, regardless of equivalent encodings.

An instance of I17 One-Proposition Set in a Knowledge Base may, alternatively, be implemented by a 'reification' construct, and is regarded as logically equivalent in this model. Similarly, all triples of properties declared for one class that denote the domain, type, and range of another property, such as the properties of E13 Attribute Assignment and its

subclasses, can be interpreted as shortcuts to an instance of I17 One-Proposition Set, and its properties, *J30 has domain (is domain of)*, *J31 has range (is range of)*, *J32 has property type (is property type of)*. Such property triples can also be interpreted as a 'reification' which is implicit in the declaring class.

As such, the class I17 One-Proposition Set plays the role of a logical interface between different ways to document a discourse about propositions within a Knowledge Base. It is particularly relevant for implementing effective queries. For documentation, the use of simpler shortcut properties will, typically, be the preferred approach.

Examples:

- the proposition set with content:
  {The skeleton in La Tomba dell'Aryballos sospeso on the left Bench (E20 Biological Object) *P2 has type* 'male' (E55 Type)} (I17) (Squires, 2013)
- the proposition set with content:
  {The skeleton in La Tomba dell'Aryballos sospeso on the left Bench (E20 Biological Object) *P2 has type* 'female' (E55 Type} (I17) (Mandolesi, 2013)
- the proposition set with content:
  {The burial arrangement in La Tomba dell'Aryballos sospeso on the left bench (E22 Human-Made Object) *is composed of* the spear found in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) (Mandolesi, 2013)
- the proposition set with content:
  {The skeleton in La Tomba dell'Aryballos sospeso on the left bench (E20 Biological Object) *forms part of* the burial arrangement in La Tomba dell'Aryballos sospeso on the left bench (E22 Human-Made Object)} (I17) (Mandolesi, 2013)
- the proposition set with content:
  {The book MS Sinai Greek 418 (E22 Human-Made Object) *has binding structure* 'unsupported' (E55 Type)} (I17) (Honey & Pickwoad, 2010)
  ['has binding structure' refers to a property, external to the CIDOC CRM, which connects a book (E22 Human-Made Object) to the type of its binding structure (E55 Type)]

In First Order Logic:

$I17(x) \Rightarrow I4(x)$
$I17(x) \Rightarrow (\exists uvw)\ [E1(u) \wedge J30(x,u) \wedge E1(v) \wedge J31(x,v) \wedge E55(w) \wedge J32(x,w)]$

Properties:

J30 has domain (is domain of): E1 CRM Entity
J31 has range (is range of): E1 CRM Entity
J32 has property type (is property type of): E55 Type

CRMinf Property Declarations

The properties are comprehensively declared in this section using the following format:

- Property names are presented as headings in bold face, preceded by unique property identifiers;
- The line “Domain:” declares the class for which the property is defined;
- The line “Range:” declares the class to which the property points, or that provides the values for the property;
- The line “Subproperty of:” is a cross-reference to any superproperties the property may have;
- The line “Superproperty of:” is a cross-reference to any subproperties the property may have;
- The line “Quantification:” declares the possible number of occurrences for domain and range class instances for the property;
- The line “Scope note:” contains the textual definition of the concept the property represents;
- The line “Examples:” contains a bulleted list of examples of instances of this property. If the example is also an instance of a subproperty of this property, the unique identifier of the subclass is added in parenthesis. If the example instantiates two properties, the unique identifiers of both properties are added in parenthesis;
  The line “Examples:” provides illustrative examples showing how the property should be used;
- The line “In first-order logic:” expresses the formal constraints of the property in terms of logical axioms in a first-order logic notation.

J1 used as premise (was premise for)

Domain:
I5 Inference Making

Range:
I2 Belief

Subproperty of:
E7 Activity. P17 was motivated by (motivated): E1 CRM Entity

Superproperty of:

Quantification:
many to many, necessary (1,n:0,n)

Scope note:
This property associates an instance of I2 Belief with the instance of I5 Inference Making that used it as a premise.

Full path:

Examples:

- the gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso (E17, I5), provided to the press by Alessandro Mandolesi on the 21st September 2013, *used as premise* the spear observed by Mandolesi at the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (I2). (Squires, 2013) (Mandolesi, 2013)

In First Order Logic:
J1(x,y) ⇒ I5(x)
J1(x,y) ⇒ I2(y)
J1(x,y) ⇒ P17(x,y)

J2 concluded that (was concluded by)

Domain:
I1 Argumentation

Range:
I2 Belief

Subproperty of:
E2 Temporal Entity. P175 starts before or with the start of (starts after or with the start of): E2 Temporal Entity
E2 Temporal Entity. P175i starts after or with the start of (starts before or with the start of): E2 Temporal Entity
E2 Temporal Entity. P185 ends before the end of (ends after the end of): E2 Temporal Entity

Superproperty of:
I7 Belief Adoption. J13 adopted interpretation (was concluded by): I12 Adopted Belief
I7 Belief Adoption. J15 assumed meaning (was assumed by): I13 Intended Meaning Belief
I15 Provenance Assessment. J21 concluded provenance (was assessed by): I14 Provenance Belief
I16 Meaning Comprehension. J23 interpreted meaning as (was interpretation by): I13 Intended Meaning Belief

Quantification:

one to many, necessary, dependent (1,n:1,1)

Scope note:

This property associates an instance of I2 Belief with the instance of I1 Argumentation that concluded it.

Full path:

Examples:

- Ian Hodder's re-examination, in 1996, of the physical relation of wall C and floor B of building 1 in the north area of Catalhöyük (I1) *concluded that* Ian Hodder believed from 1996 on, that Floor B was earlier than wall C of building 1 in the north area of Catalhöyük. (Hodder, 1999)
- The gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso (E17, I5), provided to the press by Alessandro Mandolesi on the 21st September 2013, *concluded that* the gender of the skeleton was 'male', according to Mandolesi (I2). (Squires, 2013)

In First Order Logic:

J2(x,y) ⇒ I1(x)
J2(x,y) ⇒ I2(y)
J2(x,y) ⇒ P175(x,y)
J2(x,y) ⇒ P175i(x,y)
J2(x,y) ⇒ P185(x,y)

J3 applied (was applied by)

Domain:

I5 Inference Making

Range:

I3 Inference Logic

Subproperty of:

E7 Activity. P16 used specific object (was used for): E70 Thing

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I3 Inference Logic with the instance of I5 Inference Making that used it to draw its conclusion.

Full path:

Examples:

- the gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso (E17, I5), provided to the press by Alessandro Mandolesi on the 21st September 2013, *applied* the statement "People buried with arms or weapons are mostly male" (I3). (Squires, 2013)

In First Order Logic:

J3(x,y) ⇒ I5(x)
J3(x,y) ⇒ I3(y)
J3(x,y) ⇒ P16(x,y)

J4 that (is subject of)

Domain:

I2 Belief

Range:

I4 Proposition Set

Subproperty of:

Superproperty of:

I13 Intended Meaning Belief. J16 assumed meaning (is supposed meaning in): I4 Proposition Set
I14 Provenance Belief. J19 that (is subject of): I10 Provenance Statement

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of I4 Proposition Set with the instance of I2 Belief that holds an opinion about it.

This property is part of the fully developed path from E13 Attribute Assignment through *J2 concluded that (was concluded by)*, I2 Belief, *J4 that (is subject of)*, to I17 One-Proposition Set, which is shortcut by *J33 assigned proposition (is assigned by)*.

This property is also part of the fully developed path from I2 Belief, *J4 that (is subject of)*, I4 Proposition Set, *J26 has unambiguous description (describes the formal meaning of)*, to E73 Information Object, which is strongly shortcut by *J27 that the formal meaning of (has a meaning belief)*.

Full path:

Examples:

- Dragendorff's belief [of type 29 Bowls being from the 1st century AD] that type 29 Bowls are from the 1st century AD (I4).
- Francesca Bologna's belief that Publius Cornelius Tacitus meant that "Nero was at Antium when the Great Fire broke out and did not return to Rome until the fire approached his house" (I12) *that*
  {Nero in July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Timespan)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Antium in 64AD, Italy (E53 Place)
  P133 is spatiotemporally separated from: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  }. (I4) (Bologna, 2021)

- The belief of Alessandro Mandolesi in the gender of the skeleton on the left bench in La Tomba dell'Aryballos sospeso (I2), as provided to the press on 21st September 2013, *that* {The skeleton in La Tomba dell'Aryballos sospeso on the left bench (E20 Biological Object) *P2 has type* 'male' (E55 Type).} (I17). (Squires, 2013)
- The belief of Alessandro Mandolesi in observing a spear in the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (I2) *that* {The burial arrangement in La Tomba dell'Aryballos sospeso on the left Bench (E22 Human-Made Object) *is composed of* the spear found in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17). (Squires, 2013) (Mandolesi, 2013)

In First Order Logic:

J4(x,y) ⇒ I2(x)
J4(x,y) ⇒ I4(y)

J5 holds to be

Domain:

I2 Belief

Range:

I6 Belief Value

Subproperty of:

Superproperty of:

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of I2 Belief with the I6 Belief Value that reflects the opinion of a particular E39 Actor about the truth of the associated I4 Proposition Set.

Full path:

Examples:

- Dragendorff's belief that type 29 bowls are from the 1st century AD (I2) *holds to be* TRUE (I6).
- One spear being in the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso following Alessandro Mandolesi's observation (I2) *holds to be* TRUE (I6). (Squires, 2013)
- The belief of Alessandro Mandolesi that the skeleton on the left bench in La Tomba dell'Aryballos sospeso belonged to a male person (I2), as announced to the press on 21st September 2013, *holds to be* FALSE (I6) (Squires, 2013).
- The belief of Alessandro Mandolesi that the skeleton on the left bench in La Tomba dell'Aryballos sospeso belonged to a female person (I2), as announced to the press on November 2013, *holds to be* TRUE (I6) (Squires, 2013).

In First Order Logic:

J5(x,y) ⇒ I2(x)
J5(x,y) ⇒ J6(y)

J7 is based on evidence from (is evidence for)

Domain:
I7 Belief Adoption

Range:
E73 Information Object

Subproperty of:
E7 Activity. P16 used specific object (was used for): E70 Thing

Superproperty of:

Quantification:
many to many, necessary (1,n:0,n)

Scope note:
This property associates an instance of I7 Belief Adoption with the instance of E73 Information Object that is a source of evidence for the I4 Proposition Set that was adopted.

Full path:

Examples:

- The adoption on behalf of Francesca Bologna of the belief by Tacitus concerning Emperor Nero's whereabouts at the beginning of the Great Fire of Rome (I7) *is based on evidence* from Tacitus, Publius Cornelius. *The Annals*. Book 15 [15.16]. (Bologna, 2021)

In First Order Logic:
J7(x,y) ⇒ I7(x)
J7(x,y) ⇒ E73(y)
J7(x,y) ⇒ P16(x,y)

J13 adopted interpretation (was concluded by)

Domain:
I7 Belief Adoption

Range:
I12 Adopted Belief

Subproperty of:
I1 Argumentation. J2 concluded that (was concluded by): I2 Belief

Superproperty of:

Quantification:
one to many, necessary, dependent (1,n:1,1)

Scope note:
This property associates an instance of I7 Belief Adoption with the instance of I12 Adopted Belief that was established and possibly selected from the interpretation of the source or sources referred to by the property *J14 adopted interpretation of (has adopted interpretation)*. This property implies a relation of trust in the reliability of the sources. The actual believed content, i.e., propositions about some past reality that have been adopted from the source, should be documented using the property *J4 that (is subject of)*.

Full path:

Examples:

- the gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso (E17, I5), provided to the press by Alessandro Mandolesi on the 21st September 2013, *used as premise* the lance observed by Mandolesi at the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (I2). (Squires, 2013) (Mandolesi, 2013)

In First Order Logic:

J13(x,y) ⇒ I7(x)
J13(x,y) ⇒ I12(y)
J13(x,y) ⇒ J2(x,y)
J13(x,y) ⇐ (∃uvw) [E73(u)∧ J7(x,z) ∧ I13(v) ∧ J15(x,y) ∧ I4(w) ∧ J4(y,w) ∧ J17(u,y) ∧ J16(v,w)]

J14 adopted interpretation of (has adopted interpretation)

Domain:

I12 Adopted Belief

Range:

E73 Information Object

Subproperty of:

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I12 Adopted Belief with a source or sources of interpretation from which the belief was established and possibly selected. In some cases of scholarly arguments, multiple sources referring to a common topic may have been interpreted to form a particular belief about the topic referred to.

Full path:

Examples:

- Francesca Bologna's belief that "Nero was at Antium when the Great Fire broke out and did not return to Rome until the fire approached his house" (I12) *adopted interpretation* of Tacitus, Publius Cornelius. *The Annals*. Book 15 [15.6] (E73). (Bologna, 2021)

In First Order Logic:

J14(x,y) ⇒ I12(x)
J14(x,y) ⇒ E73(y)

J15 assumed meaning (was assumed by)

Domain:

I7 Belief Adoption

Range:

I13 Intended Meaning Belief

Subproperty of:

I7 Belief Adoption. J2 concluded that (was concluded by): I2 Belief

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I7 Belief Adoption with an instance of I13 Intended meaning Belief about a meaning believed to be expressed in the source or sources referred to by the property *J14 adopted interpretation of (has adopted interpretation)*.

Full path:

Examples:

- The adoption on behalf of Francesca Bologna of the belief by Tacitus, concerning Emperor Nero's whereabouts when the Great Fire of Rome broke out *assumed meaning* the belief of Francesca Bologna that what Publius Cornelius Tacitus meant was "Nero was at Antium when the Great Fire of Rome broke out, and that he only returned to Rome when the fire approached his house." (I13). (Bologna, 2021)

In First Order Logic:

J15(x,y) ⇒ I7(x)
J15(x,y) ⇒ I13(y)
J15(x,y) ⇒ J2(x,y)

J16 assumed meaning (is supposed meaning in)

Domain:

I13 Intended Meaning Belief

Range:

I4 Proposition Set

Subproperty of:

I2 Belief. J4 that (is subject of): I4 Proposition Set

Superproperty of:

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of I13 Intended Meaning Belief with the instance of I4 Proposition Set that represents the meaning assumed by the holder of the belief to have been intended by the respective source. The latter source can be documented with the property *J17 about (has interpretation)*.

Full path:

Examples:

- Francesca Bologna's belief that Publius Cornelius Tacitus meant that "Nero was at Antium when the Great Fire broke out and did not return to Rome until the fire approached his house" (I13) assumed meaning
  {Nero in July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Time-Span)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Antium in 64 AD, Italy (E53 Place)
  P133 is spatiotemporally separated from: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, AD (E52 Time-Span)
  P7 took place at: Rome, in 64AD, Italy (E53 Place)
  } (I4). (Bologna, 2021)

In First Order Logic:

J16(x,y) ⇒ I13(x)
J16(x,y) ⇒ I4(y)
J16(x,y) ⇒ J4(x,y)

J17 about (has interpretation)

Domain:

I13 Intended Meaning Belief

Range:

E73 Information Object

Subproperty of:

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I13 Intended Meaning Belief with the instance of E73 Information Object that was a source of or evidence for the interpretation of its intended meaning. If sources are fragmentary about or complementary to a specific topic, more than one source may have been used.

Full path:

Examples:

- Francesca Bologna's belief that Gaius Suetonius Tranquillus meant that Nero was singing in Rome while it was burning from July 19 64AD *about* the extant book *De Vita Caesarum*, attributed to Gaius Suetonius Tranquillus.

In First Order Logic:

J17(x,y) ⇒ I13(x)
J17(x,y) ⇒ E73(y)

J18 assumed provenance (was assumed by)

Domain:
I7 Belief Adoption

Range:
I14 Provenance Belief

Subproperty of:
E7 Activity. P17 was motivated by (motivated): E1 CRM Entity

Superproperty of:

Quantification:
many to many, necessary (1,n:0,n)

Scope note:
This property associates an instance of I7 Belief Adoption with an instance of I14 Provenance Belief about the source or sources referred to by the property *J14 adopted interpretation of (has adopted interpretation)*, which justifies the conviction that the trusted and adopted content of the source, or its copy at hand, is actually identical, or sufficiently close to the assumed original and its context of creation.

Full path:

Examples:

- The adoption on behalf of Francesca Bologna of the belief by Tacitus concerning the whereabouts of Emperor Nero at the time the Great Fire of Rome started (I7) *assumed provenance* her belief about the authenticity of Tacitus, Publius Cornelius. *The Annals*. Book 15 [15.16] (I14).

In First Order Logic:
J18(x,y) ⇒ I7(x)
J18(x,y) ⇒ I14(y)
J18(x,y) ⇒ P17(x,y)

J19 that (is subject of)

Domain:
I14 Provenance Belief

Range:
I10 Provenance Statement

Subproperty of:
I2 Belief. J4 that (is subject of): I4 Proposition Set

Superproperty of:

Quantification:
many to many, necessary (1,n:0,n)

Scope note:
This property associates an instance of I14 Provenance Belief with the instance of I10 Provenance Statement that holds an opinion about it.

Full path:

Examples:

- Francesca Bologna's belief about the authenticity of Tacitus, Publius Cornelius. *The Annals*. Book 15 (I14) *that* the copy of Tacitus, Publius Cornelius. *The Annals*. Book 15 [15.16] which she obtained from the British Museum in 2021 represents a text written by the ancient Roman historian, Publius Cornelius Tacitus (I10).

In First Order Logic:

J19(x,y) ⇒ I14(x)
J19(x,y) ⇒ I10(y)
J19(x,y) ⇒ J4(x,y)

J20 is about the provenance of (has provenance claim)

Domain:

I10 Provenance Statement

Range:

E70 Thing

Subproperty of:

E89 Propositional Object. P129 is about (is subject of): E1 CRM Entity
I4 Proposition Set. J28 contains entity reference (is referred to in): E1 CRM Entity

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I10 Provenance Statement with an instance of E70 Thing, the provenance of which the statement describes.

Full path:

Examples:

- The statement: "The exemplar of The Merchant of Venice, Quarto 1 (1600) owned by The British Library, shelf number BL C.34.k.22 was published in 1600 AD by Thomas Heyes" (I10) *is about the provenance of* the exemplar of The Merchant of Venice, Quarto 1 (1600), owned by the British Library, shelf number BL C.34.k.22 (E70)

In First Order Logic:

J20(x,y) ⇒ I10(x)
J20(x,y) ⇒ E70(y)
J20(x,y) ⇒ P129(x,y)
J20(x,y) ⇒ J28(x,y)

J21 concluded provenance (was assessed by)

Domain:

I15 Provenance Assessment

Range:

I14 Provenance Belief

Subproperty of:

I1 Argumentation. J2 concluded that (was concluded by): I2 Belief

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I15 Provenance Assessment with an instance of I14 Provenance Belief that constitutes the conclusion of the assessment. An instance of I15 Provenance Assessment may conclude more than one instances of I14 Provenance Belief, typically about different objects considered in the same assessment.

Full path:

Examples:

- The assessment by Ernst Pernicka et al. concerning the provenance of the Nebra Sky Disk (I15) *concluded provenance* of their belief that the Nebra Sky Disk dates to the Early Bronze Age (I14). (Pernicka et al., 2020)

In First Order Logic:

J21(x,y) ⇒ I15(x)
J21(x,y) ⇒ I14(y)
J21 (x,y) ⇒ J2(x,y)

J22 interpreted meaning of (was interpreted by)

Domain:

I16 Meaning Comprehension

Range:

E73 Information Object

Subproperty of:

E7 Activity. P16 used specific object (was used for): E70 Thing

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I16 Meaning Comprehension with the instance of E73 Information Object that was the source of or evidence for the interpretation of its intended meaning. If sources are fragmentary about or complementary to a specific topic, more than one source may have been used.

Full path:

Examples:

- My understanding of the statements about Emperor Nero's whereabouts in Rome while it was burning from 19th July 64 AD (I16) *interpreted meaning* of the extant book *De Vita Caesarum* (E73) by Gaius Suetonius Tranquillus.

In First Order Logic:

J22(x,y) ⇒ I16(x)
J22(x,y) ⇒ E73 (y)
J22 (x,y) ⇒ P16(x,y)

J23 interpreted meaning as (was interpretation by)

Domain:

I16 Meaning Comprehension

Range:

I13 Intended Meaning Belief

Subproperty of:

I1 Argumentation. J2 concluded that (was concluded by): I2 Belief

Superproperty of:

Quantification:

one to many, necessary, dependent (1,n:1,1)

Scope note:

This property associates an instance of I16 Meaning Comprehension with the instance of I13 Intended Meaning Belief that was the result of the interpretation of the intended meaning of the analysed source(s).

Full path:

Examples:

- My understanding of the statements about Emperor Nero's whereabouts in Rome while it was burning from 19th July 64 AD (I16) *interpreted meaning as* believing that it meant Nero was singing in Rome while it was burning from 19th July in 64 AD (I13).

In First Order Logic:

J23(x,y) ⇒ I16(x)
J23(x,y) ⇒ I13 (y)
J23(x,y) ⇒ J2(x,y)

J24 held at least for (is at least validity of)

Domain:

I11 Situation

Range:

E52 Time-Span

Subproperty of:

Superproperty of:

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I11 Situation with the instance of E52 Time-Span that defines the minimal time of asserted validity of the property instances constituting this situation. The associated time-span constitutes a necessary part of the identity of this situation. Any different association of a time-span even to the same constituting propositions of this situation will identify another instance of I11 Situation.

Note that the respective situation may have had shorter duration than the one given by the property *P82 at some time* within to the associated time-span, but the same propositions may quite well have prevailed for longer and other times. In order to make a statement about how long at least the propositions of that situation uninterruptedly prevailed, the property *P81 ongoing throughout* should be used for the associated time-span.

There is no means to declare that the propositions of that situation did not occur outside the given time-span.

There are two typical cases for the determination of the related instance of E52 Time-Span. In the first, it is the temporal extent of some instance of E2 Temporal Entity, such as an observation activity, and documented with *P4 has timespan (is timespan of)*: this then documents the validity of the asserted instance of I11 Situation for the complete instance of E2 Temporal Entity, even if the actual time-span is not known, and can be regarded as a phenomenal timespan. In the second, the instance of E52 Time-Span is a date range declared in or derived from historical sources or provided by dating methods: then it is a declarative timespan.

Full path:

Examples:

- The situation reported by Shaykh Abu Abdallah (Ibn Battuta) about the Maristan in Cairo, Egypt (I11) *held at least for* the time-span of Ibn Battuta's visit in 1326AD (E52) (Gibb 1926, pp. 50-51)
- The situation reported by Shaykh Abu Abdallah (Ibn Battuta) about the Muslim quarters in Chinese cities (I11) *held at least for* the time-span of Ibn Battuta's visit in 1354AD (E52) (Gibb 1926, pp. 283)
- The situation reported by Antonio Pigafetta from Magellan's voyage at 21st of October 1520 about the existence of a strait to the Pacific *held at least for* 21st and 22nd of October 1520 (E52) (Pigafetta and Stanley, 1874: 58)

In First Order Logic:

$J24(x,y) \Rightarrow I11(x)$
$J24(x,y) \Rightarrow E52(y)$

J25 is encoded by

Domain:

I4 Proposition Set

Range:

E62 String

Subproperty of:

Superproperty of:

Quantification:

one to many (0,n:0,1)

Scope note:

This property associates an instance of I4 Proposition Set with a “serialization” of its content in the format of a knowledge representation language. There may be more than one ontologically equivalent formal encodings of the same propositions.

In a Knowledge Base implementation, the content of an instance of I4 Proposition Set may be represented by the content of a Named Graph, but only if the propositions are encoded in the data model of the Knowledge Base and held to be true by the maintainers of a Knowledge Base because they become part of the stated knowledge. In this case, the platform-internal relation between the URI of the Named Graph and its content are regarded as equivalent to *J25 is encoded by*, and the property should formally not be instantiated.

Full path:

Examples:

- {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* ‘male’ (E55 Type)} (I17)
  is encoded by
  “<crm:E20_Biological_Object rdf:about=" https://cidoc-crm.org/crminf/examples/Aryballos_Skeleton">
  <rdfs:label xml:lang="en"> The skeleton on the left bench in La Tomba dell'Aryballos sospeso </rdfs:label>
  <crm:P2_has_type>
  <crm:E55_Type rdf:about="http://vocab.getty.edu/aat/300025928">
  <rdfs:label xml:lang="en">men (male humans)</rdfs:label>
  </crm:E55_Type>
  </crm:P2_has_type>
  </crm: E20_Biological_Object>” (E62). (Squires, 2013)

In First Order Logic:

J25(x,y) ⇒ I4(x)
J25(x,y) ⇒ E62(y)

J26 has unambiguous description (describes the formal meaning of)

Domain:

I4 Proposition Set

Range:

E73 Information Object

Subproperty of:

E1 CRM Entity. P129i is subject of (is about): E89 Propositional Object

Superproperty of:

Quantification:

one to many (1,n:0,1)

Scope note:

This property associates an instance of I4 Proposition Set with an instance of E73 Information Object that expresses in a natural language the content of the former as propositions that are or could, in principle be, encoded in a knowledge representation language.

The formulation of these propositions should be unambiguous at least within the context of provenance of the information object and the context of documenting them as the content of the instance of I4 Proposition Set. For a textual representation, rules of a normal scholarly consensus that it is unambiguous should be applied.

This property is part of the fully developed path from I2 Belief, *J4 that (is subject of)*, I4 Proposition Set, *J26 has unambiguous description (describes the formal meaning of)*, to E73 Information Object, which is strongly shortcut by the property J27 that the formal meaning of (has a meaning belief).

Full path:

Examples:

- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'male' (E55 Type)} (I17)
  has unambiguous description
  "The skeleton found on the left bench of La Tomba dell'Aryballos sospeso, Doganaccia di Tarquinia, Tuscany, Italy, by Prof. Alessandro Mandolesi on the 21th of September 2013 belongs to the remains of a male person" (E73). (Squires, 2013)
- The proposition set with content:
  {Nero July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Timespan)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Rome in 64AD, Italy (E53 Place)
  P10 falls within (contains): Nero Singing (E7 Activity)
  P2 has type: Singing (E55 Type)
  P14 carried out by: Nero Claudius Caesar Drusus Germanicus (E21)
  P4 has timespan: July 19, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  P132 spatiotemporally overlaps with: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  }
  has unambiguous description "Nero Claudius Caesar Drusus Germanicus was singing in Rome while it was burning from July 19 in 64 AD" (E73). (Bologna, 2021)

In First Order Logic:

J26(x,y) ⇒ I4(x)
J26(x,y) ⇒ E73(y)
J26(x,y) ⇒ P129(y,x)

J27 that the formal meaning of (has a meaning belief)

Domain:

I2 Belief

Range:

E73 Information Object

Subproperty of:

Superproperty of:

Quantification:

many to one (0,1:0,n)

Scope note:

This property associates an instance of I2 Belief with an instance of E73 Information Object that expresses the believed propositions in a sufficiently unambiguous way and in a form that they are or could, in principle be, encoded in a knowledge representation language.

This property is a strong shortcut of the fully developed path from I2 Belief, *J4 that (is subject of)*, I4 Proposition Set, *J26 has unambiguous description (describes the formal meaning of)*, to E73 Information Object. It is introduced into this model for the convenience of the user, when the implied instance of I4 Proposition Set appears not to be a separate object of discourse within this documentation context.

Full path:

I2 Belief. J4 that (is subject of): I4 Proposition Set. J26 has unambiguous description (describes the formal meaning of): E73 Information Object

Examples:

- The belief of Prof. Alessandro Mandolesi in the gender of the skeleton on the left bench in La Tomba dell'Aryballos sospeso as provided to the press on the 21th of September 2013 (I2) *that the formal meaning of*
  "The skeleton found on the left bench of La Tomba dell'Aryballos sospeso, Doganaccia di Tarquinia, Tuscany, Italy, by Prof. Alessandro Mandolesi on the 21th of September 2013 belongs to the remains of a male person" (E73) ["*holds to be* TRUE (I6)", see examples for J5]. (Squires, 2013)

In First Order Logic:

J27(x,y) ⇒ I2(x)
J27(x,y) ⇒ E73(y)
J27(x,y) ⇔ (∃u) [I4(u) ∧ J4(x,u) ∧ J26(u,y)

J28 contains entity reference (is referred to in)

Domain:

I4 Proposition Set

Range:

E1 CRM Entity

Subproperty of:

E89 Propositional Object. P67 refers to (is referred to by): E1 CRM Entity

Superproperty of:

I10 Provenance Statement. J20 is about the provenance of (has provenance claim): E70 Thing
I17 One-Proposition Set. J30 has domain (is domain of): E1 CRM Entity
I17 One-Proposition Set. J31 has range (is range of): E1 CRM Entity

Quantification:

many to many, necessary (2,n:0,n)

Scope note:

This property associates an instance of I4 Proposition Set with an instance of E1 CRM Entity that appears as an element of one or more propositions in the content of the former.

This property serves on one side to relate an instance of I4 Proposition Set to other contexts of interest, in particular when its content is or cannot be represented as a Named Graph in the same knowledge base. On the other hand, it plays an important structural role in this model for expressing constraints to the content of an instance of I4 Proposition Set or one of its subclasses.

Full path:

Examples:

- The proposition set with content:
  {Nero in July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Timespan)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Antium in 64AD, Italy (E53 Place)
  P133 is spatiotemporally separated from: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  }
  contains entity reference Antium in 64AD, Italy (E53 Place) (Bologna 2021)

In First Order Logic:

J28(x,y) ⇒ I4(x)
J28(x,y) ⇒ E1(y)
J28(x,y) ⇒ P67(x,y)

J29 contains property type (is property type in)

Domain:

I4 Proposition Set

Range:

E55 Type

Subproperty of:

E89 Propositional Object. P67 refers to (is referred to by): E1 CRM Entity

Superproperty of:

I17 One-Proposition Set. J32 has property type (is property type of): E55 Type

Quantification:

many to many, necessary (1,n:0,n)

Scope note:

This property associates an instance of I4 Proposition Set with an instance of E55 Type that appears as property type in one or more propositions in the content of the former.

This property plays an important structural role in this model for expressing constraints to the content of an instance of I4 Proposition Set or one of its subclasses.

Full path:

Examples:

- The proposition set with content:
  {Nero in July 19, 64 AD (E93 Presence)
  P164 is temporally specified by: July 19, 64 AD (E52 Timespan)
  P195 was a presence of: Nero Claudius Caesar Drusus Germanicus (E21 Person)
  P167 was within Antium in 64AD, Italy (E53 Place)
  P133 is spatiotemporally separated from: The Great Fire of Rome (E5 Event)
  P1 is identified by: incendium magnum Romae (E41 Appellation)
  P4 has timespan: July 19-27, 64 AD (E52 Timespan)
  P7 took place at: Rome in 64AD, Italy (E53 Place)
  } *contains property type* P195 was a presence of (E55 Type) (Bologna, 2021)

In First Order Logic:

J29(x,y) ⇒ I4(x)
J29(x,y) ⇒ E55(y)
J29(x,y) ⇒ P67(x,y)

J30 has domain (is domain of)

Domain:

I17 One-Proposition Set

Range:

E1 CRM Entity

Subproperty of:

I4 Proposition Set. J28 contains entity reference (is referred to in): E1 CRM Entity

Superproperty of:

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of I17 One-Proposition Set with an instance of E1 CRM Entity that must appear as the only domain instance of the proposition in the content of the former.

This property is part of the fully developed path from E13 Attribute Assignment through *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, *J30 has domain (is domain of)*, to E1 CRM Entity, which is shortcut by *P140 assigned attribute to (was attributed by)*.

Full path:

Examples:

- The proposition set with content:

{The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'male' (E55 Type)} (I17) *has domain* the skeleton in La Tomba dell'Aryballos sospeso on the left bench (E20) (Squires 2013)

- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'female' (E55 Type)} (I17) *has domain* the skeleton in La Tomba dell'Aryballos sospeso on the left bench (E20) (Mandolesi 2013)
- The proposition set with content:
  {The burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22 Human-Made Object) *is composed of* the spear found in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) *has domain* the burial arrangement in La Tomba dell'Aryballos sospeso on the left bench (E22) (Mandolesi 2013)
- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *forms part of* the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) *has domain* the skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20) (Mandolesi 2013)
- The proposition set with content:
  {The book MS Sinai Greek 418 (E22 Human-Made Object) *has binding structure* 'unsupported' (E55 Type)} (I17) *has domain* the book MS Sinai Greek 418 (E22) (Honey & Pickwoad, 2010)

[See comments for examples of I17 One-Proposition Set]

In First Order Logic:

J30(x,y) ⇒ I17(x)
J30(x,y) ⇒ E1(y)
J30(x,y) ⇒ J28(x,y)
J28(x,y) ∧ I17(x) ⇒ J30(x,y) OR J31(x,y)
[the superproperty *J28 contains reference entity (is referred to in)* may not be instantiated directly for instances of I17 One-Proposition Set]

J31 has range (is range of)

Domain:

I17 One-Proposition Set

Range:

E1 CRM Entity

Subproperty of:

I4 Proposition Set. J28 contains entity reference (is referred to in): E1 CRM Entity

Superproperty of:

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of I17 One-Proposition Set with an instance of E1 CRM Entity that must appear as the range of the proposition in the content of the former.

This property is part of the fully developed path from E13 Attribute Assignment through *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, *J31 has range (is range of)*, to E1 CRM Entity, which is shortcut by *P141 assigned (was assigned by)*.

Full path:

Examples:

- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'male' (E55 Type)} (I17) *has range* 'male' (E55) (Squires 2013)
- The proposition set with content:
  {The burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22 Human-Made Object) *is composed of* the spear found in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) *has range* the spear found in La Tomba dell'Aryballos sospeso (E22) (Mandolesi 2013)
- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *forms part of* the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) *has range* the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22) (Mandolesi 2013)
- The proposition set with content:
  {The book MS Sinai Greek 418 (E22 Human-Made Object) *has binding structure* 'unsupported' (E55 Type)} (I17) *has range* 'unsupported' (E55 Type) (Honey & Pickwoad, 2010)

  [See comments for examples of I17]

In First Order Logic:

J31(x,y) ⇒ I17(x)
J31(x,y) ⇒ E1(y)
J31(x,y) ⇒ J28(x,y)
J28(x,y) ∧ I17(x) ⇒ J30(x,y) OR J31(x,y)
[the superproperty *J28 contains reference entity (is referred to in)* may not be instantiated directly for instances of I17 One-Proposition Set]

J32 has property type (is property type of)

Domain:

I17 One-Proposition Set

Range:

E55 Type

Subproperty of:

I4 Proposition Set. J29 contains property type (is property type in): E55 Type

Superproperty of:

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of I17 One-Proposition Set with an instance of E55 Type that must appear as the only property type of the proposition in the content of the former.

This property is part of the fully developed path from E13 Attribute Assignment through *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, J*32 has property type (is property type of)*, to E1 CRM Entity, which is shortcut by *P177 assigned property of type (is type of property assigned)*.

Full path:

Examples:

- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'male' (E55 Type)} (I17) *has property type* 'P2 has type' (E55). (Squires 2013)
- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'female' (E55 Type)} (I17) *has property type* 'P2 has type' (E55). (Mandolesi 2013)
- The proposition set with content:
  {The burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22 Human-Made Object) *is composed of* the spear found in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) *has property type* 'P46 is composed of' (E55). (Mandolesi 2013)
- The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *forms part of* the burial arrangement on the left bench in La Tomba dell'Aryballos sospeso (E22 Human-Made Object)} (I17) *has property type* 'P46i forms part of' (E55). (Mandolesi 2013)
- The proposition set with content:
  {The book MS Sinai Greek 418 (E22 Human-Made Object) *has binding structure* 'unsupported' (E55 Type)} (I17) *has property type* 'has binding structure' (E55). (Honey & Pickwoad, 2010)

  [See comments for examples of I17]

In First Order Logic:

J32(x,y) ⇒ I17(x)
J32(x,y) ⇒ E55(y)
J32(x,y) ⇒ J29(x,y)

J33 assigned propositions (is assigned by)

Domain:

E13 Attribute Assignment

Range:

I17 One-Proposition Set

Subproperty of:

Superproperty of:

Quantification:

many to one, necessary (1,1:0,n)

Scope note:

This property associates an instance of E13 Attribute Assignment with an instance of I17 One-Proposition Set that describes the proposition made and believed to be true.

This property constitutes a formal logical alternative to specifying the proposition made by an instance of E13 Attribute Assignment via *P140 assigned attribute to (was attributed by), P141 assigned (was assigned by)* and *P177 assigned property of type (is type of property assigned)*. As such, it is of importance for querying knowledge bases compatible with either model.

This property forms part of the following three (3) fully developed paths from E13 Attribute Assignment through:

- *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, *J30 has domain (is domain of)* to E1 CRM Entity, which is shortcut by *P140 assigned attribute to (was attributed by)*.
- *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, *J31 has range (is range of)* to E1 CRM Entity, which is shortcut by *P141 assigned (was assigned by)*,
- *J33 assigned proposition (is assigned by)*, I17 One-Proposition Set, *J32 has property type (is property type of)* to E1 CRM Entity, which is shortcut by *P177 assigned property of type (is type of property assigned)*.

This property is a shortcut for the path from E13 Attribute Assignment through *J2 concluded that (was concluded by)*, I2 Belief, *J4 that (is subject of)*, I4 Proposition Set, *J5 holds to be* to I6 Belief Value (= "TRUE").

Full path:

E13 Attribute Assignment. J2 concluded that (was concluded by): I2 Belief. J4 that (is subject of): I4 Proposition Set. J5 holds to be: I6 Belief Value (= "TRUE")

Examples:

- The gender classification of the skeleton on the left bench in La Tomba dell'Aryballos sospeso provided to the press by Prof. Alessandro Mandolesi on the 21th of September 2013 (E17, I5) *assigned proposition*
  The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'male' (E55 Type)} (I17) (Squires 2013)
- The gender analysis of the skeleton on the left bench in La Tomba dell'Aryballos sospeso provided to the press by Prof. Alessandro Mandolesi on the 18th of October and academically published in 2013 (E17, S4) *assigned proposition*
  The proposition set with content:
  {The skeleton on the left bench in La Tomba dell'Aryballos sospeso (E20 Biological Object) *P2 has type* 'female' (E55 Type)} (I17) (Mandolesi 2013)
- The examination of MS Sinai Greek 418 by Nicholas Pickwoad in November 2003 (E13) *assigned proposition*
  The proposition set with content:
  {The book MS Sinai Greek 418 (E22 Human-Made Object) *has binding structure* 'unsupported' (E55 Type)} (I17) (Honey & Pickwoad, 2010)

[See comments for examples of I17]

In First Order Logic:

J33(x,y) ⇒ E13(x)
J33(x,y) ⇒ I17(y)
J33(x,y) ⇒ P140(x,u) ∧ J30(y,u) ∧ P141(x,v) ∧ J31(y,v) ∧ P177(w) ∧ J32(y,w)
J33(x,y) ⇒ (∃u) [I2(u) ∧ J2(x,u) ∧ J4(u,y) ∧ J5(u, “TRUE”)] believed to be true!
E13(x) ⇒ (∃uvw) [E1(u) ∧ P140(x,u) ∧ E1(v) ∧ P141(x,v) ∧ E55(w) ∧ P177(x,w)]
J2(x,y) ∧ E13(x) ⇒ J33(x,y)
P140(x,y) ⇒ (∃u) [I17(u) ∧ J33(x,u) ∧ J30(u,y)]
P141(x,y) ⇒ (∃u) [I17(u) ∧ J33(x,u) ∧ J31(u,y)]
P177(x,y) ⇒ (∃u) [I17(u) ∧ J33(x,u) ∧ J32(u,y)]

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