47th joint meeting of the CIDOC CRM SIG and ISO/TC46/SC4/WG9; 40th FRBR- CIDOC CRM Harmonization meeting.
24&26 June 2020

University of Oslo, Faculty of arts, Unit for digital documentation

Online on Zoom platform

Participants

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DAY 1: 24 June 2020

House rules for the meeting (CEO)

Welcome and generic introduction with respect to goals of the meeting (MD)

Topic of the Meeting: to produce an official release of the CIDOC CRM, to be submitted to ISO for revision (and approval).

Last SIG meeting: decisions related to the content of CRM –to produce v7.0 (the new official release for the community, currently available on the website).

The version which will ensue following the editing work undertaken by this SIG meeting (7.0.1?) will be submitted to ISO for approval.

Issues concerning the new release will take precedence over other –less pressing –issues over this meeting, but participants should not be discouraged from raising any issue they wish nonetheless.

GB: proposal on procedure

Add an AOB section to the final session of the meeting to discuss issues such as requests for membership and social media representation of the SIG.

No objections to that; **Proposal accepted.**

SESSION 1.1; Facilitator: Thanasis Velios

Issue 456: Compatibility Statement; Issue facilitator: CEO)

CEO brought the SIG to date with the proposal by the SIG editorial team, namely to close issue for lack of feedback and/or interest by the SIG members. Given the time-frame for submitting the text to ISO is limited, and seeing as the text as it appears now was approved by ISO for the last release of the standard, the editorial team prefer to keep the text as is.

Discussion

MD commented that the compatibility statement that was issued before in the community release of the CIDOC CRM caused friction among our community and the ISO team, so this was a compromise that was accepted by all. In favor of not changing it. It could be revised, but preferably following the next ISO release.

GB: The ISO edition being a chief factor in considering this issue, how should we proceed with the submission to ISO?

MD: we need to contact the representatives from the respective ISO WG.
(1) Axel Ermert
(2) Nick Crofts
(3) Patrick le Boeuf

CEO: It should go through Axel Ermert.

VOTE to not alter the section *Compatibility with the CRM*, at least not before the release of the ISO version.

Result: 12 members in favor, none against.

Decision: The section "Compatibility with the CRM" will remain as is, at least until the ISO release.

The text can be found in the appendix 3 .

Issue 459: Modelling Principles; issue facilitator: CEO

Ratification of the editorial changes made on the introduction of the CIDOC CRM since the last meeting following the e-votes.

The text of the introduction (where all changes were applied) can be found appendix 3.

Note on Procedure: The decisions listed below were reached by one collective vote at the end of debating the issue (17 votes in favor, none against). No disagreement to the proposed changes was registered before this point.

Logical Expressions in CRM (comment No.2) in text of Appendix 3
The SIG ratified the result of the e-vote that resolved to replace the symbol used for equivalence ($\equiv$) with the double pointed arrow ($\Leftrightarrow$) and the symbol used for implication ($\supset$) with the double arrow ($\Rightarrow$).

Minor editorial changes were also implemented and presented to the CRM SIG prior to the meeting. The SIG was asked to comment on and ratify these as well.

VOTE: to accept the changes in the text implemented by the editorial team,[1] and to ratify the result of the e-vote regarding the logical operators used to express the CRM in FOL.
Result: 6 SIG members in favor, none against
Decision: The text for the section "About the logical expressions used in the CIDOC CRM" presented by CEO is accepted as such and will appear in v7.0. The logical operators used in the text will be updated accordingly.

HW: CEO will update the logical operators in the text of the CIDOC CRM in version 7.0.

Reality, Knowledge Bases and CIDOC CRM (comment No.3 in the Appendix 3)
 Explaining the CIDOC CRM to non-logicians or non-IT people is a cumbersome process. In order to avoid stacking too much information in the introductory text, which would discourage normal people from continuing to read it, the editorial team added some references in footnotes for anyone interested to look them up.

VOTE: The SIG was asked to comment and ratify the addition of footnotes (5) and (6)
Result: 12 SIG members voted in favor of the proposed change, there were no negative votes.
Decision: Footnotes (5) and (6) are added to the official release (v7.0) of CIDOC CRM.

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[1] For an overview see: https://docs.google.com/document/d/1u-3yOYrtH5KuFB5EAkbuZqRu2G83ysCvfoLFw55hIVc/edit?usp=sharing

Editing of the text on the scope of what the CRM aims at modelling (comment No.4 in the text of Appendix 3)

VOTE: The SIG was asked to comment and ratify the change implemented by the editorial group.
Result: 10 members voted in favor of the proposed change, there were no negative votes
DECISION: The edited text will appear in the official release (v7.0) of CIDOC CRM.

Trivial editing; addition of a clause to improve legibility of the text (comment No.5 in the text of Appendix 3)
VOTE: Addition of the "because"–clause in the text. Remove the sentence in the grey marking (residue from previous editing, it no longer relevant).
Result: 8 members voted in favor of the proposed change, no negative votes.
DECISION: The edited text will appear in CIDOC CRM v7.0.

Spacetime diagram of the statue of Laocoon and the impact it has had on J.J. Winckelmann' s thought
Revisiting the new diagram (HW by ML).

Discussion: not part of this issue, there' s a designated issue for this.

Decision: do not discuss it in the context of Issue 459.

Overall decision for issue 459:
Vote: Ratification of the editorial changes made on the introduction of the CIDOC CRM since the last meeting following the e-votes.

Result: 17 SIG members in favor, none against**.**

Decision: changes will appear on the text of the official CIDOC CRM v7.0.1 release.

The issue closed.

Issue 458: Proofreading of scope notes of P79-P80-P81-P82
What the present SIG meeting had to resolve was the new scope notes for the properties used to describe how inner and outer boundaries of intervals are combined in information integration.

Note on procedure: the decision regarding the changes to be implemented on the scope notes of properties P79 through P82 was reached by one vote at the end of the discussion. Changes implemented can be found in the Appendix:

new scope note for P79 beginning is qualified by
Motivation for the proposal: the old scope note stated that it was the property, which carried the information of the arguments rather than the note that was being attached.

No comments by the SIG members present

New scope note for P80 end is qualified by
Motivation for the proposal: the old scope note stated that it was the property, which carried the information of the arguments rather than the note that was being attached.

No comments by the SIG members present

New scope note for P81 ongoing throughout

Motivation for the proposal: there was a discussion regarding how to combine inner and outer bounds. **P81 ongoing throughout** describes an inner bound. If there are multiple opinions about inner bounds, then the outermost bounds of the smallest interval that covers all the opinions regarding the actual extent over which some (temporal) entity was ongoing, should result from all the observations made.

There is a question about the procedure that the standard does not resolve –namely what the procedure by means of which the maintainer of a knowledge base would integrate the observations and create an interval that would ensue from taking these observations into account. The addition to the scope note reflects this notion.

Discussion/proposals:

- The examples should contain an instance of two non-contradictory minimal extents to illustrate the case in point.
  MD will produce an example and start an email vote after the meeting **(HW)**.
  To be done in a new issue
- **[GB]** Maybe to discuss the examples in the afternoon session.
  MD: to make sure that the examples are non-trivial and well-referenced he needs more time than the lunchbreak.

New scope note for P82 at some time within

Motivation for the proposal: on a par with what was proposed for P81, but for maximal extents.

Discussion/proposals:

- add an example to capture the content of the added text –**HW** to MD, but not for the afternoon session. To be discussed and put up for an e-vote.

VOTE:

- Accepting the minor modifications in the scope notes of P79 & P80.
- Accepting the added text for P81 & P81.
- Starting a new issue for discussing examples of integrating (i) non-contradictory minimal extents and (ii) non-contradictory maximal extents –**HW** to MD.

Result: 14 SIG members in favor of the proposal, none against.

DECISION: accept proposed changes,the issue closed. Start a new issue on the examples for P81/82.

The details of the changes can be found in the appendix.

NEW ISSUE: examples for P81 & P82

Topic: produce examples for the integration of (i) non-contradictory minimal extents and (ii) non-contradictory maximal extents to illustrate P81 & P82, respectively.

Background: Upon discussing MD's proposal to edit the scope notes for P81 and P82 (adding text to capture the integration of different sources documenting non-contradictory minimal AND maximal extents, the SIG appointed him to provide such examples that will instantiate the respective properties.

Discussion: The examples must be referenced, as this practice demonstrates an actual need.

HW: **MD** to look-up the examples.

ISSUE 386

CEO presented his HW on how to harmonize the subclasses of E24 Physical Human-Made Thing (E22 Human Made Object, E25 Human Made Feature) with the new scope note for E24.The solution to the problem he proposed was (i) to delete the *no assumptions* clause from the definition, which allowed to characterize as "human-made", objects and features that had merely been scratched on by a human agent (the moon, the surface of a cave etc.) and (ii) to add text that better illustrated the kind of intervention required for something to be felicitously described as "human-made". The details of the HW for E22 and E25 can be found in the [Appendix](#).

Upon discussing this issue SS observed a number of typos in the scope note of E24 Human-Made Thing, which were all edited. The details can be found in the [Appendix](#).

Discussion:

It relates to issue 442 –should be taken into account in retrospective.

GB: *in an objective way* in the scope note of E22 is a bit difficult to define, but he's OK with keeping it in the scope note if everyone else agrees. Maybe discuss it in a separate issue. MD seconded, [the issue was formulated](#).

VOTE on the changes in the scope notes for E22 and E25, so that they are consistent with the scope note of E24.
Result: 14 positive/no negative votes.
Decision: The changes are accepted. The issue closed.

NEW ISSUE: Formulate the philosophical underpinnings of crm and its relation to reality and the objectivity of observations.
CEO: (comment) Such a philosophical inquiry would possibly end up revising the scope note of Physical Object as well, cause the phrase has been taken from the scope note of E19.

The SIG has already delved in that topic –as part of the changes made in the introduction (Reality, Knowledge Bases and CIDOC CRM). But it would be nice to explore some more, even if we don't get concrete results.

Issue 471

Introduce a new graphic in the CRM introduction.

MD: presented two versions of the slides (1st problematic, 2nd not so much). Wishes No.2 to serve as a prototype for diagrams exemplifying STVs and reasoning about them. Wants to know if the group thinks that this version of the diagram gives the correct impression of the symbolic move in space-time.

Discussion/comments (for the 2nd diagram):

- **SS**: likes it in general, nice that you have the different kinds of objects interacting. Capitalize Roman
- **GH**: 3d diagrams could be helpful, making the space one dimensional is hard;

- **MD**: 3d doesn't help. If you add 2 dimensions for the space, but there is actually a geometric connection, wants to be close to what archaeologists do (have columns and boxes for duration, always one-dimensional space line)
- **GH**: could make it easier for people to depict these things
- **TV**: events stretch across different geographic areas. Smaller bubbles of text maybe // gradient color: used to denote uncertainty why mark space as gradient?
- **SS**: place doesn't cease to exist after the end of an event. So dotted lines continue to the top of the graphic
- **CEO**: would like to take away the green arrow at the bottom of the diagram –no moving space.
- **MD**: keep the line, remove the arrowhead in space.
- **GB**: if the diagram is a one-off, he's fine with it, but if we'll need to produce more such diagrams then we'd have to go through the specifics of making such diagrams in a separate issue.

DECISION: evote for the diagram once it's ready.

HW to **MD** to redo the graph taking the following into consideration

- smaller event bubbles
- dotted lines for places and other things that carry on existing till present should extend to the top part of the timeline.
- space axis: arrow-head to be removed. Space does not move.
- add a legend with relevant CRM classes
- Unknown roman creator → change to Unknown Roman creator
- things that cease to exist, should not end in a pointy arrow but in an arrow with a full stop –like what happens to Winckelmann with *Winckelmann's death* (so his mother, the Unknown Roman creator, the Original statue …)

HW to MD to introduce a heading and an accompanying text that would explain the diagram.

SESSION 1.2; Facilitator: Chrysoula Bekiari.
Issue 453

The cardinalities for P4 has timespan and P170 defines time were changes over the last SIG meeting. But they were wrong. MD presented his HW whereby he tried to fix them.

P4 has timespan
Edited typos and the cardinality.

The cardinality was changed to *many-to-one* (0,1:0,n), which is to say that *a temporal entity may not have a link P4 has time span pointing to a time span*, which is wrong. But a temporal entity has **exactly ONE** time-span, alternatives are not expressed in the cardinality. Many temporal entities may point to the same time span BUT each temporal entity cannot point to more than one time-span. It is necessary that each temporal entity have time span.

The details can be found in the appendix

MD explained that the cardinality was going the wrong direction. It should be from E61 Time Primitive to E52 Time-Span and not the other way around.

A time primitive may connect to no time span and it may point to more than one time-spans. A time-span may be defined by a time primitive: if it is phenomenal it is typically defined as the timespan of an E4 Period or an E2 Temporal Entity; in the case that a time-span is defined by P170 it is not defined through P4.

The time-span can not appear as the range of P170 –but if it does, then it can only be defined by this one time primitive.

Discussion/comments

GH: a time primitive can define multiple time spans?

MD: a time primitive may have more syntactic variants and the mathematical identity of the time-span is given by the time-span itself. There are multiple ways that E61 Time Primitive may express the same time-span. Because we define instances of E61 Time Primitive as syntactic forms and not as mathematical abstractions, all the primitive values expressing a mathematical quantity can have multiple formulations.

GH. That's to say cardinality goes the other way round. We can have several instances of E61 Time Primitives that could define the same instance of E52 Time-Span. What was stated before was that one time primitive may define more than one time-spans.

MD: So, the proposed cardinality is wrong. Instead it should reflect that the same timespan may have more than one incoming time primitives. And then there's the question if the same time primitive can define more than one time-span, and that was not the case. So the cardinality previously ascribed to the property was the correct one –many to one (0,1:0,n).

GB: How would one explain the semantic purport of P170? Why did we need to declare yet another property linking instances of E52 to instances of E61?

MD: this is to report declarative timespans. The observed timespan is not phenomenal and as such it cannot be observed. We cannot say that the time span is the time span of a given period.

SS: using P170 means that the time primitive determines the time-span, whereas the other properties are best approximating the phenomenal time span.

MD: **Proposal** maybe a phrase justifying the cardinality should be included in the scope note –SS volunteered to add that

GH: **Proposal** include in the examples an instance of a declarative timespan –a case in point would be the period that a given law is put into effect *a given law is in effect starting from day x …*

VOTE: to make the changes on P4 (corrected cardinalities, and typos), to not change the cardinality of P170 but to add a phrase explaining its cardinality.
Result: 8 positive votes, no negative ones.
DECISION: Accepted.

HW for after the break to SS: add a phrase in the scope note of P170 explaining its cardinality (see [below](#), and [appendix](#))

The issue closed

Issue 428

CEO presented his HW

E59 primitive value

The last paragraph was not really legible, MD volunteered to redraft it by the last session of the day.

DECISION: HW for MD (see [below](#) and [appendix](#))

E61 Time Primitive

CEO proposed to delete the last two paragraphs, as they repeat text from E59 (we have decided to reference super-classes/properties in the text rather than duplicating text in their sub-classes/properties.

Discussion/Proposal:

GB: In many cases, the necessary information to correctly interpret a class is contained in the scope note of its superclass. The reference to the superclass (where the reader can find all the relevant information) could include a standardized text like *please read the text of Exxxx carefully –reiterating IsA*

CB: this way we create dependencies between the scope notes, and they are not easy to understand from the modelling perspective.

CEO: he copied in text from the super-class in the case of E22 and E25 to increase legibility, despite the decision to not add text from superclasses. It should be decided on for each case separately. in the case of E61, the scope note starts by declaring it a subclass of E59. No reason to add to that.

MD:
- the repetition should only be allowed in cases where the subclass is distinguished by the superclass by some particular prominent feature. We should not copy text from a superclass to its subclasses as a rule. There is no clear-cut criterion to decide which are classes for which the isA should be explicitly mentioned in the scope note vs. the ones that don't need such a mention.
- Given that E61 isA E41 Appellation, that should also be reflected in the scope note; MD proposed to close issue 428 and start a new issue to redraft the scope note of all primitive values that are isA E41 Appellation, to capture this fact. Seconded by CEO and SS.

Vote: Changes on the scope note of E61 as proposed by CEO
–**HW** by **MD** to follow in the afternoon session.
Result: 11 votes in favor, none against.
Decision: Accept. The issue closed.

NEW ISSUE: redraft the scope note of all primitive values that are isA E41 Appellation, to capture this fact.

Issue 367

PROPOSAL: to close the issue.

MD: The example is problematic. We can close the issue and start a [new issue](#) on the examples of E13 Attribute Assignment.

TV: will look up real examples from conservation studies –we need at least two. **(HW)**

Issue closed.

NEW ISSUE: revise the examples of E13 Attribute Assignment

Issue 468

Motivation/background:

TV presented evidence in favor of shifting the domain of P126 employed from E11 Modification to E7 Activity. The event type that motivated the proposal was that of an unsuccessful modification (f.i. the application of a solvent to remove something that did not bring about the desired result). Not extending the domain of P126 is to say that a certain action of modification took place, that did not modify anything. TV has proposed a scope note to reflect the shift in the domain of P126, but in view of MD's concerns about moving up properties to high-level generic classes, he preferred to discuss this first and then present the HW. The alternative would be to alter the scope note of E11 Modification.

Discussion

MD: the CRM is not a classification system, so the boundaries of what is considered a modification by an expert and what did not lead to a modification is a question of typology.
Even in cases where the application of a solvent to modify a physical object was ineffective, there are still traceable residues of that chemical substance. So that may constitute an instance of modification as well.

Proposal:
Review the scope note of E11 Modification so that it can be applied in cases, where there are no traceable changes on the modified object as well. Add a clause stating that whatever treatment is performed on an object is regarded an instance of E11 Modification in the CRM universe –regardless its success/failure to do so. Further typing of E11 Modification would allow to distinguish among successful and unsuccessful ones (i.e. ones that did not bring about the intended result).

GB: thinks that such a definition of E11 is counterintuitive and a contradiction and would yield false positives all the time (possibly false negatives too)

MD: a non-issue given the principles (**A**) Recall over precision [[if there are modifications that do not leave any forensic traces, this is a borderline, and for recall purposes we go for the broader interpretation]] & (**B**) CRM not a classification system [[what is of interest is the characteristic set of properties that can serve as the basis for a reasonable definition of a given process –in this case modification]]. So, the typical experts' classification can change to increase recall.

TV & SS: this notion could be modelled through activity plans to avoid the contradiction of a modification that didn't result in modifying anything.
Did not pass.

Final proposal:

Close the issue & abandon the HW. Start a new issue to change the scope note of E11 Modification as described above (modifications that did not succeed in bringing about the intended changes on some object –either in part or in total; **HW** for TV to include the border cases.

Vote on the Final Proposal:
Result: 10 votes in favor, none against.
Decision: accept –**close issue**.

NEW ISSUE: Change the scope note of E11 Modification

Change the scope note of E11 Modification as described above (modifications that did not succeed in bringing about the intended changes on some object –either in part or in total;

HW for TV to include the border cases.

Issue 489:

SS presented the alternative labels for **P164 during (was time-span of)** and **P167 at (was place of)**.

Motivation: old labels read strange and do not convey the intended meaning. New labels are:

- P164 is temporally specified (temporally specifies)
- P167 was within (includes)

E-vote for newly proposed names:

- Change **P167 at (was place of)** to **P167 was within (includes)**:
    - o Result: 12 in favor, none against
    - o Decision: accept
- Change **P164 during (was time-span of)** to **P164 is temporally specified by (temporally specifies)**:
    - o Result: 9 in favor, none against
    - o Decision: Accept

Start new issue on reformulating the scope note for P164 to capture that the timespan can be declarative. The issue closed.

NEW ISSUE: reformulate the scope note for P164

Motivation: the scope note must also capture declarative timespans.

SESSION 1.3; Facilitator: George Bruseker.

Issue 428 –HW by MD: scope note of E59 Primitive Value

MD presented his HW. The SIG did some editorial work on that. The details can be found in the Appendix.

VOTE: on the scope note of E59 Primitive Value as proposed by MD
Result: 13 votes in favor, none against
Decision: Accept, the issue closed.

Issue 453 –HW by SS: scope note of P170 defines time

SS presented his HW –phrase added to the scope note that justifies the cardinality of the property. The details can be found in the Appendix.

VOTE: on the scope note of P170 defines time as proposed by SS.
Result: 12 votes in favor, none against
Decision: Accept, the issue closed.

Issue 462

Proposal: P181 has amount to be deprecated in favor of P90 has value;

Motivation: P181 has amount seems to be making no difference compared to its superproperty, hence should be deleted

Discussion/comments:

RS: after the 44th SIG (Paris) the SIG has modelled P90a/b has upper/lower bound. If P181 is kept in the model, then we would have to resort to a similar practice in this case too (P181a/b). Which means that we'd be buying into two superfluous properties, not just one.

MD: The example listed in P181 should move up to P90.

VOTE: Deprecate P181 has amount, move the examples up to P90 has value
Result: 9 SIG members in favor, none against
Decision: Accept

The details can be found in the Appendix

Issue 476

Proposal: Introduce a new property (**Pxxx represents entity of type**) to facilitate documenting the type of an entity represented by a visual item, where the actual individual represented is of no interest to the documentalist (either the object was imagined and never existed, or –if it existed at all –its identity is considered really trivial and knowledge about it does not contribute much to understanding/appreciating/documenting the visual item itself). The alternative would be to introduce entities and assign them identities and a type –even though they never existed (except for the depiction).

Discussion:

The usefulness of the property was debated, given that the range of P138 represents is set to E1 CRM Entity, i.e. it can directly link to E55 Type if necessary. In the case of photographs the things represented have necessarily existed at the time the photograph was taken, so there is no issue there with creating hypothesized entities.

MD: The proposed property must reflect how it is different from P138 represents in both its uses:
- E36 Visual Item –P138 represents: E1 CRM Entity –P2 has type: E55 Type
- E36 Visual Item –P138 represents: E55 Type

If it fails to do so, it shouldn't be introduced in the model at all.

The case that such a property might be useful is when the object represented is either a conceptualization (something that never was except in the particular instance of E36 Visual Item) or an unidentified/unidentifiable particular of some type. In both instances, the type can be recovered, the particular not so much. In essence the property serves as a shortcut when one needs to bypass the thing represented altogether.

RS: proposed to add this clarification to the scope note

SS: suggested that the examples need to be reworked to capture this reading.

<u>Debate whether this property will appear in the CIDOC CRM version to be submitted to ISO:</u> all senior SIG members present against (MD, SS, CEO, GB, TV, RS).

MD proposed that no new property be introduced in the model in the version submitted to ISO, unless it has been well thought of and judged necessary.

Summary –outcome of discussion: Postpone reaching a decision until **RS** has brought back an updated proposal incorporating the changes suggested by the SIG (define it as a shortcut and redraft the examples); which should be before session 2.3. Then, if the SIG agrees it could be given an identifier and be used by the community –it is not to go to the version submitted to ISO.

HW for **RS**

Issue 475

Motivation: current scope note of E10 Transfer of Custody requires that an instance of E10 involves physical custody of an object and at the same time acknowledges physical possession to be one of the options.

Proposal: Change in the scope note of E10 Transfer of Custody to not presuppose physical possession in the first place –**HW** by **RS** & **GB**.

Discussion: The SIG members support the proposal, and discussed how to best formulate the scope note. There was extensive editing on the first sentence of the scope note but for lack of time, **RS** volunteered to fix the 1st sentence of the 2nd paragraph by session 2.3 as **HW**.

The details can be found in the [Appendix](#).

Issue 426

Discussion/comments:

MD:

- maybe add a comment to the scope note, some sort of remark on how to document the time of validity using presence construct?

- It appears not to have any super-/sub-properties; this should be checked.
- Needs be assigned an identifier.

SS:

- Declaring that a property is NOT a subproperty of another one is, but resolves potential ambiguities and misinterpretations.
- Online editing –instead of swamping the first sentence with e.g., maybe better to add a sentence referring to typical examples –as a practice.

MD: the concept of *support* should be made more specific –not as something that is part of an object; it has to be distinct in a sense. Emphasis on where we draw the borderline btw something supporting a structure and something being construed as a part of a structure. Examples illustrating a supporting structure probably include frames for paintings, bases to statues, shelves to exhibits/books. Maybe it's the intended function that determines whether something is a support of some sort.
containers are easier to describe in a concise and comprehensive way.

RS: added a sentence to best capture containers/supports of all sorts "*Typical examples of containers or supports include shelves, folders or boxes that provide a surface upon which is intended for other physical objects to be placed for storage, display, transport or other functions*"

CB: This property makes sense from the point of view of art galleries and museums (and how they store their items for moving purposes for instance),

TV: as well as from the point of view of conservation (particular boxing practices to preserve manuscripts)

HW to Rob to polish this up, incorporating the feedback of the SIG, in order for the scope note to be reviewed in session 2.3

HW to CEO to fix the FOL representation

The discussion will continue in [Session 2.3](#)

The details can be found in the [Appendix](#).

Issue 442

Presentation by MD –postpone action until Session 2.3.

DAY 2: 26 June 2020

Introduction:

Regarding recording the sessions: The purpose is to help with the minutes; i.e. to better document the discussion on complex issues that tend to go multiple ways. Under no circumstances will the recordings be shared with anyone outside the editorial team.

Call for active participation: Aside resolving issues, the purpose of the SIG meetings is to acclimate newcomers with the principles guiding the group's decisions. If something is not self-evident, attendees are welcome to pose questions.

Brief report on the CIDOC CRM editorial team's work in the period leading up to CIDOC CRM v7.0:

CEO: Since the lockdown we decided to host regular editorial team's virtual meetings to prepare the release of CIDOC CRM v7.0. There were 7 such meetings, <u>the minutes of which will made publicly available as well</u>/ (http://www.cidoc-crm.org/Meeting/47th-cidoc-crm-and-40th-frbr-crm). The objective of these meetings was to resolve trivial issues (spelling errors, systematizing how things are presented in the CIDOC CRM document, etc.), as well as formulate issues in a decidable manner for the SIG to decide upon ([through e-votes](#)). The outcome of these meetings was CIDOC CRM v7.0 as it appears on the website.

The remaining issues have been scheduled for the current SIG meeting.

The plan is to publish a version with an ISBN number, which would be easier to refer to.

Discussion;

MD: The idea is to make v7.0 an official release of the CIDOC CRM, so that we have a stable point of reference. The version submitted to ISO will be a later one. There are a number of significant changes in this release –many concepts regarded obsolete/superfluous have been deprecated, structural changes have occurred too. We are aware that this practice creates backward incompatibility issues, but we resorting to solutions that are no longer relevant is more problematic.

It is essential to finalize the official release as soon as possible and then produce migration guidelines.

GB: maybe instead of dubbing the official version **v7.0,** we should best go for **v7.0.1** --because we have there have made decisions affecting what appears now on the site as v7.0.

Everyone in agreement.

SESSION 2.1; Facilitator: Stephen Stead.
Issue 497: reformulate the scope note for P164

MD presented his HW –additions to the scope note of P164 so that it reflects it's about instances of declarative E52 Time-Span. Details in the [appendix](#).

Discussion/Proposals:

GB: these new constructs should probably come with a graphical representation to show how they are best put to work. Should be considered thematically when we produce new didactic material.

SS: The scope note explicitly mentions P170 for declarative time spans, but only alludes to what should be done when documenting phenomenal timespans. P4 has timespan should also be explicitly referenced in the scope note.

Everyone in agreement

Vote on accepting the scope note proposed by MD
Result: 11 SIG members present in favor, none against
DECISION: accept the edit.

The issue closed

Issue 490

MD presented the issue hoping for feedback by the SIG members.

It was agreed that the issue is not formulated in a decidable form and the point of bringing it up was to determine whether people think we should pursue it some more;

MD proposed to introduce a new property that describes the relation btw URIs standing for content of different symbolic specificity. The issue is about the intuitions we have concerning the identity of a file we point to by a URI and not about the actual identity of the file in IT terms. The IT identity would be binary, but we're thinking in terms of content, which is much more abstract.

TV: proposed to add a paragraph to the implementation in rdf document,

Vote the proposal by **MD**.
Results: 9 SIG members in favor to keep working on the new property, none against
Decision: work on the new property will continue –**HW** to MD, GB. Note: ask for advice by the Libraries community.

Issue 463

MD presented his HW. Some editorial changes were proposed and the new scope note for E37 Mark was put up for a vote. The changes in the text can be found in the appendix.

VOTE: to include the new scope note to CIDOC CRM 7.0.1

Result: 10 in favor, none against

Decision: accept the new scope note.

Issue 457

Discussion/Comments:

MD: the issue is not presented in a decidable form yet, needs more discussion and should be ultimately decided by an e-vote.

   (a) common software: different email votes per software proposed
   (b) if the SIG decides that diagrams are to be drawn in a given way (using a particular software) does that mean that it proscribes diagrams being made differently?

SS: It is not a question of dictating how CIDOC CRM diagrams will be made but what sort of templates will the SIG be providing to anyone who wishes to represent the model using such diagrams. It is a matter of workload and maintaining templates, not advertising software.

GB: the official documentation of the CRM produced by the SIG should adhere to what we decide regarding the diagrams (once we've reached a decision).

MD: before settling this issue, we'd have to determine the proposed uses, document them carefully and inform our decision based on the uses these diagrams should have.

ET: the template does not have to be used to retrospectively edit legacy editions of the CRM. It should only inform newer versions f.i. CIDOC CRM v7.0.1 and on.

MD: but we have to take into consideration all the effort it takes to redo a tutorial using the new template, for version 7 and on.

GB: no more than the effort required to make a new tutorial

TV: it is unclear whether the issue is only about colors or which software to use or if it should scrutinize every possible design-related detail –font style/size, arrows, lines (style and thickness), size of the bubbles, orientation of hierarchical representations, etc.

MD: he'd rather we inform our decision by a style guide, f.i. isA is represented by double-line arrows, and once the style guide is ready and agreed upon, then we should see which software allows said options.

GB: the different subtopics have already been teased apart, we should continue working on each of them separately: (1) style guide, (2) software, (3) color, (4) diagrams to be made over using the decided template.

MD: they're deeply intertwined –if the style guide cannot be supported by a software, then we'd have to decide against using that particular software. f.i. Draw.io does not allow double-line arrows, so we cannot represent isA there, according to our style guide.

SS: two alternative ways to proceed: (a) look at available software, and let it drive our choices for representing classes/properties/direct & indirect isA etc. or (b) decide how we want to represent these things and let that decision drive our option of software package

CEO: we need a certain style guide, and then if the software can deliver these options, all the better. If not, we might want to reconsider how we will be representing them or if we will opt for a different software that can adequately represent them.

MD: if no consensus is reached on one style guide, then we can put all the proposed styles to the test. it is possible that we might end up with as many style guides as there are purposes. Geometry and color are two distinct issues –the geometry can influence our decision, color not so much.

Final proposal:

(i)   come up with **geometric style guide** (<u>no colors</u>) for each purpose the diagrams are going to serve and who is supposed to be using them: (i) publications, (ii) didactic proposes & (iii) whole class hierarchy. The style guide is not dependent on the use it is for. The style guide is going to inform the use of software.

(ii)   once we have a style guide for each use case, then we'll produce colored versions of them, to decide on the impact of the proposed color schemes on the overall set of diagrams (diagrams using the color code that SIG-members proposed.

VOTE on Final proposal –part (i): Develop a geometric style-guide (no color) with use cases and user community clearly defined.
Result: 11 SIG members present in favor –none against.
Decision: Accept

VOTE on Final proposal –part (ii): Try different color schemes on the style guide – once the geometric style guide has been determined.

Result: 11 SIG members present in favor –none against
Decision: Accept.

HW to determine the geometric style guide for representing the CRM diagrams: **ML**, <mark>MD, GB, CEO</mark>?

SESSION 2.2; Facilitator: Thanasis Velios.

Issue 483

Discussion: a multi-faceted issue, not in a decidable form.

CEO: The thing with E33 he commented on was that we must make sure that it includes spoken text too. it shouldn't exclusively be about instances of written text.

Decision: leave it for now, subtopics discussed separately.

Issue 450:

Intro by MD: When we changed the interpretation of E54 Dimension we didn't fully update the scope note –the phrase "An instance of E54 Dimension represents the true quantity, independent from its numerical approximation, e.g. in inches or in cm." remained in the scope note by mistake. The scope note was edited accordingly. The details of the changes can be found in the appendix.

Discussion/comments:

SS:

- following our current practices, the value and unit of measurement of the dimension should be represented in square brackets at the end in the examples–it should not be mixed with the dimension itself.
- the scope note has some obscure points, needs further editing

Proposal:

Rework the examples, given the fact that units and values are included in the examples –to be done in a new issue.

Redraft the scope note (**HW to SS**) to make it absolutely clear in what sense the comparability of the values obtained for different dimensions can be warranted.

Decision: Proceed as proposed –(i) new issue on the examples and (ii) edit the scope note for E54: both **HW** assigned to **SS**

NEW ISSUE: revision of the examples for E54 Dimension

HW: **SS** to edit the examples of E54

Issue 383

Proposal to close Issue 383 –no loose ends there, so there is no point to keep it open.

Decision: everyone in agreement. Issue closed.

The **HW** by MD on E33 Linguistic Object and P190 has symbolic content will be reviewed on issue 483 – not part of this issue.

Issue 274

Summary of the issue:

GB presented a classification of sound recordings instantiating a set of prototypical sounds and commented on the similarity of these sounds to visual images (instances of E36) from a conceptual point of view –in that they create identifiable patterns and have intellectual/conceptual aspects.

However, given the scope note of E36 starts by defining visual items as *intellectual or conceptual aspects of recognizable marks and images*, it could not possibly be expanded to refer to the sounds animals produce. The proposed solution to that: only consider such sounds in as much as they represent the outcome of an activity performed by a human agent (collection), which is what grants them an intellectual/conceptual aspect.

Creating a distinct class for that would be warranted to the extent that there are properties linking said sound with an event of producing it or recording it etc.

Discussion/comments:

MD: Natural history is definitely part of the CRM's scope –be it CRMsci or some other family model. However: the notion it captures is too wide. Distinguish among the actual recording (see FRBRoo – where there is no new class for recording stuff) and the ensuing recorded sound.
Multimedia information is a specialization for the E73 Information Object –so not on a par with recorded musical performance, frog sounds, etc.

OE: the distinction btw the recording of a sound and the "iconographic sound" is fundamental. The sound of a motorcycle as such and the same kind of sound incorporated in a musical score for instance.

GB: a sound that's recorded once and then gets remixed in some other sound file has qualities as a sound –and can be traced back to the event of producing and recording it.

SS: that's on a par with incorporating text. The notion of archetypal sound lies in there being some recognizable blueprint the identity of which does not depend on the circumstances of its use.

MD: It's not about showing that a class has properties, but whether the properties are relevant for information integration. It should be interesting to record who produced a particular sound. But if the question one aims at answering is for what category of things this sound is typical, then this needs to be more elaborated. In any case comparing that to the practices assumed in FRBRoo.
Regarding the connection to Oral History, the spoken text is an instance of E73 Information Object as such. So, the sounds are not excluded by E73 and do not require a specific class.

TV: Contemporary art uses archetypical sounds in artwork –sound art exhibitions. Curators of such exhbitions probably need to be able to integrate information on the (recorded?) sounds used in the exhibition.

OE: add at least one example of audio integration in E73 Infromation Object and E90 Symbolic Object.

Decision: reconsider the HW –continue working on that.

TV will ask sound art colleagues to point him in the right direction with regards to sound integration.

MD will rework the scope notes and examples for E90 Symbolic Object and E73 Information Object. GB and OE to contribute to that.

Issue 483

Subtopics discussed separately:

(i) Edited scope note for E33 Linguistic Object

MD presented his HW (edit the scope note of E33 Linguistic Object, so that it takes into consideration the new property P190 has symbolic content).

The details of the changes can be found in the [appendix](#).

Discussion:

CEO, OE: To resolve the orientation to written text at the expense of spoken text we should add an example of recordings of spoken text –not transcripts of recorded speech but the recordings as such. The examples could include

- Dialectal data –maybe CEO.
- Ethnological data –maybe MR can help with that.
- Examples pulled from P190 to make sure that there's some sense of continuity
- Instances of spoken text recorded and documented –maybe MR can help with that.

Proposal: Keep the reworked scope note for version 7.0.1 and continue working on the examples for the next release

Vote: Keep the proposed scope note of E33 Linguistic Object for CIDOC CRM v7.0.1 and work up the examples in future releases ([in a new issue](#))
Result: 11 votes in favor, none against.
Decision: Accept

For the procedure: The issue cannot close just yet –multiple subtopics to be dealt with in this Issue –will be done in [the return session](#).

NEW ISSUE: revise examples for E33 Linguistic Object

CEO, OE: To resolve the orientation to written text at the expense of spoken text we should add an example of recordings of spoken text –not just transcripts of recorded speech but the recordings as such. But if we can have an audio and a transcript for it. The examples could include

- Dialectal data – **HW: CEO**.
- Ethnological data –maybe MR can help with that.
- Examples pulled from P190 to make sure that there's some sense of continuity
- Instances of spoken text recorded and documented –maybe MR can help with that.
- Online tutorial for CIDOC CRM (SS in audio, but the transcripts are also available)

MD: Illuminated canonical edition of the Holy Bible –to show that the canonical text is rendered by illuminations (at least in part).

AF: best not illustrate by the Holy Bible, maybe a different text. Let's not get into debates about which one is the canonical form. Each manuscript is a different linguistic object –differences due to copying errors, etc.

SESSION 2.3; Facilitator: Christian-Emil Ore
Issue 450 –HW by SS to edit the scope note of E54 Dimension

SS presented the HW to the SIG –see the appendix.

Discussion/Proposal:

Re. the examples: it was acknowledged that the only example to refer to the temporal extent of the measurement was the one with Christie's hammer price for Van Gogh's Sunflowers in a vase. It was proposed that the scope note & examples in their present form go to the official release of the CRM and that the examples be reviewed (but in later versions, not for the official release).

Vote: on the proposal above.
Result: 11 votes in favor, none against
Decision: Accept

Issue 483

Subtopics discussed separately:

(ii)   Transitivity Statement; HW by CEO –reviewed by the CIDOC CRM Editorial Group.

MD presented the properties whose scope notes were affected by the updated transitivity statement (CIDOC CRM_v.7.0_26-6-2020; p. xviii) and asked the SIG to ratify the decision reached by the CIDOC CRM Editorial team.

The details regarding the transitivity statement and the affected properties can be found in the appendix.

Vote: properties affected by the Transitivity Statement
Result: 15 SIG members present in favor, none against.
Decision: accept

(iii) P139 has alternative form; edit the scope note –HW by MD

MD presented his HW –amended scope note for P139 has alternative form.

Discussion:

- spelling and grammar check.
- check whether the examples reflect the scope note –we're talking about objects in the scope note, might create confusion to the readers.

Vote: the amended scope note as found in the appendix.
Result: 14 SIG members present in favor, none against.
Decision: accept

(iv) P102 has title—add new examples by MD

MD presented his HE –two new examples for the property.

Discussion: minor editing took place.

Vote: on the examples (as found in the appendix)
Result: 14 SIG members present in favor, none against.
Decision: accept.

(v) P121 overlaps with & P122 borders with; amended the scope notes –HW by MD

MD presented his HW. There was a lot of editing –for grammar and spelling. In the end the SIG members voted whether they wanted the proposed changes to be incorporated in the scope notes of P121/122.

Vote on the amended forms of P121 and P122 (the details of the changes can be found in the appendix):
Result: 14 in favor, none against
Decision: accept changes.

(vi) E4 Period –editing.

There was a proposal during the meeting in Athens to take a paragraph out of the scope note of E4 Period. The editorial team decided against it.

Discussion:

MD: The decision is documented, but the argument is missing in both cases (Athens SIG meeting and editorial team's online meeting).

CEO: since we didn't seem to be motivated enough to delete it –to the extent that we didn't document why it might have to be deleted –we shouldn't need to be more thorough in rebutting this proposal.

MD: there was a question regarding the cardinality of P160 that might have to do with it.

CEO: proposed that we put this to rest –and also close the issue, and discuss the cardinalities of P160 (insofar as they need be revised) in a separate issue.

CB: that was the decision of the editorial team (June 2nd, 2020); i.e. to start **TWO new issues**, concerning:
   (a) the scope of E53 (498) and
   (b) a change in the cardinality of P160 (499).
The issues still do not appear in the issues list as of now, but will do so presently.

Vote: to ratify the decision of the editorial team (to NOT delete the paragraph), to revise the scope note of E53 and the cardinality of P160 in separate issues
Result: 7 SIG members present in favor, none against
Decision: accept.

Proposal to close issue 483:
Decision: accept

Issue 426 –HW by RS.

RS presented the amended scope note for Pxxx holds or supports, according to the feedback received by the SIG.

Discussion regarding the scope note:

- problems with the cardinality; originally set to many-to-many.

MD prefers to make the cardinality one-to-many. According to the examples (at least the real ones) there seems to be a unique support for other physical objects. Otherwise, it creates problems for the definition of Place.

- no superproperty
- transitive

DECISION: P198 holds or supports is introduced to the CIDOC CRM.

Discussion regarding the examples:

RS was asked to add references for the examples (Harvard style –if in a catalog, point to that).

SS: proposed that since the examples work (even Nos.2 &3 that are ficticious), they should appear in the official release of the CIDOC CRM and then be gradually replaced by actual, well-referenced ones. This would be done in a [separate issue]() though, not the current one.

Vote:
- scope note as is in the appendix;
- cardinality set to one-to-many,
- lack of a superproperty,
- the examples as they are now.

Result: 10 SIG members in favor of the proposed changes, none against.
Decision: P198 holds or supports is introduced to the CIDOC CRM. **For the details of the decision**: see [appendix]()

The issue closed

NEW ISSUE: reference and enhance the examples of P198 holds or supports.

DECISION: The examples of P198, especially the fictitious ones should be gradually replaced by actual, well-referenced ones. The references should be in Harvard Style.

AOB-managerial issues
Membership applications:

Thomas Hansli: has filed for two applications;
- (a) **University of Zurich –Swiss Art Research Infrastructure project (SARI);** work in collaboration with NC & GB
- (b) **Swiss Federal Institute of Architecture –Institute for History and Theory of Architecture;** work in collaboration with ML. it's his understanding that since ML is involved in HW and the maintenance of the standard, he could do so in a more active manner –as a formal member of the SIG. The fact that he is the applicant is because he is the contact person for the organization.

Vote: membership for the Swiss Federal Institute of Architecture
Result: 14 SIG members in favor, none against.
Decision: accept – links and logo to be shared with CB and the SIG.

George Bruseker:

> On behalf of Takin.solutions –consulting on semantic data and work with CIDOC CRM. Interested in formally participating in the CIDOC CRM SIG.

Vote: membership for Takin.solutions
Result: 15 SIG members in favor, none against.
Decision: accept – links and logo to be shared with CB and the SIG.

Specify the decision-making procedures the SIG resorts to.

Rules on how to publish issue and what things can be decided in the SIG without further notice. New membership is always welcome, but there are things that new members are not aware of when it comes to deciding etc.

To the benefit of newcomers, we should explicitly formulate the rules whereby we reach conclusions/decisions.

Aside that, there is also a document with guidelines on how to write scope notes –it's a work in progress, it will be shared through the SIG list to be commented on (MD).

TV has produced document with guidelines on how to write CRM examples and the submission process.

All these are existing issues to be consulted.

Next SIG meetings –according to schedule

    (a) a meeting in Crete has already been announced -4 days in October 2020.
    (b) a virtual or hybrid meeting before October –no consensus on the time of the meeting.
        a. send around a doodle to decide on that –around the end of August.
    (c) Offer to hold a SIG meeting in Liege (2021) and another one in Rome (2021) –where do we stand on those?
        a. We are willing to hold the in-person meetings as announced last October, however, it doesn't seem wise to start planning just yet. We would have to assess whether it's feasible to hold them when the time comes.

Feedback by SIG members re. the process of having an online meeting.

CEO: off the top of his head –the most well-prepared issues ran more smoothly. We should keep that in mind. HW was not glossed over. Proposal to continue the online meetings.

Appendix 1: List of abbreviated names in the text

AF	Achille Felicetti	PIN, University of Florence
AK	Athina Kritsotaki	ICS-FORTH
AV	Athanasios Velios	University of the Arts London
CEO	Christian-Emil Ore	University of Oslo
CB	Chrysoula Bekiari	ICS-FORTH
DA	Dimitris Angelakis	ICS-FORTH
ET	Eleni Tsouloucha	ICS-FORTH
FM	Francesca Murano	University of Florence
GB	George Bruseker	Takin.solutions
GG	Günther Görz	Friedrich-Alexander-Universität, Erlangen-Nürnberg
MD	Martin Doerr	ICS-FORTH
MF	Mark Fichtner	Germanises Nationalmuseum, Nürnberg
MN	Massoomeh Niknia	Kharazmi University
ML	Matteo Lorenzini	ETH Zürich
MR	Mélanie Roche	National library of France
MvR	Muriel van Ruymbeke	University of Liege
MYF	Myriel Fichtner	Universität Bayreuth
NC	Nicola Carboni	University of Zurich; SARI
NG	Nils Geißler	Universität zu Köln
OE	Øyvind Eide	Universität zu Köln
PF	Pavlos Fafalios	ICS-FORTH
PE	Philipp Eisenhuth	Universität Bayreuth
PM	Philippe Michon	Canadian Heritage Information Network
RS	Rob Sanderson	Previously J Paul Getty Trust; will be Yale University
SlS	Slavina Stoyanova	Universität zu Köln
SS	Stephen Stead	Paveprime Ltd
TH	Thomas Hànsli	University of Zurich
VA	Vincent Alamercery	LARHRA, Université de Lyon

Appendix 2: Amendments decided during 47th CIDOC CRM Meeting

Compatibility

Users intending to take advantage of the semantic interoperability offered by the CIDOC CRM should ensure conformance with the relevant data structures. Conformance pertains either to data to be made accessible in an integrated environment or intended for transport to other environments. Any encoding of data in a formal language that preserves the relations of the classes, properties, and inheritance rules defined by this International Standard, is regarded as conformant.

Conformance with the CIDOC CRM does not require complete matching of all local documentation structures, nor that all concepts and structures present in this International Standard be implemented. this International Standard is intended to allow room both for extensions, needed to capture the full richness of cultural documentation, and for simplification, in the interests of economy. A system will be deemed partially conformant if it supports a subset of subclasses and sub properties defined by this International Standard. Designers of the system should publish details of the constructs that are supported.

The focus of the CIDOC CRM is the exchange and mediation of structured information. It does not require the interpretation of unstructured (free text) information into a structured, logical form. Unstructured information is supported, but falls outside the scope of conformance considerations.

Any documentation system will be deemed conformant with this International Standard, regardless of the internal data structures it uses; if a deterministic logical algorithm can be constructed, that transforms data contained in the system into a directly compatible form without loss of meaning.

No assumptions are made as to the nature of this algorithm. "Without loss of meaning" signifies that designers and users of the system are satisfied that the data representation corresponds to the semantic definitions provided by this International Standard.

Issue 386

E24 Human-Made Thing (SS's edits)

E24 Physical Human-Made Thing

Subclass of: E18 Physical Thing
                 E71 Human-Made Thing
Superclass of: E22 Human-Made Object
                 E25 Human-Made Feature
                 E78 Curated Holding

Scope Note: This class comprises all persistent physical items of any size that are purposely created by human activity. This class comprises, besides others, Human-Made objects, such as a sword, and Human-Made features, such as rock art. For example, a "cup and ring" carving on bedrock is regarded as an instance of E24 Physical Human-Made Thing.

                 Instances of Human-Made thing may be the result of modifying pre-existing physical things, preserving larger parts or most of the original matter and structure, which poses the question if they are new or even Human-Made, the respective interventions of production made on such original material should be obvious and sufficient to regard that the product has a new, distinct identity and intended function and is human-made. Substantial continuity of the previous matter

and structure in the new product can be documented by describing the production process also as an instance of E81 Transformation.

Whereas interventions of conservation and repair are not regarded to produce a new Human-Made thing, the results of preparation of natural history specimens that substantially change their natural or original state should be regarded as physical Human-Made things, including the uncovering of petrified biological features from a solid piece of stone. On the other side, scribbling a museum number on a natural object should not be regarded to make it Human-Made. This notwithstanding, parts, sections, segments, or features of a physical Human-Made thing may continue to be non-Human-Made and preserved during the production process, for example natural pearls used as a part of an eardrop.

Examples:
- the Forth Railway Bridge (E22) (The Forth Railway Bridge centenary 1890-1990 ICE Proceedings, 1990, Vol.88(6), pp.1079-1107.
- the Channel Tunnel (E25) (Holliday, I., Marcou, G., and Vickerman, R. W., 1991)
- the Historical Collection of the Museum Benaki in Athens (E78) (Georgoula, E., 2005)
- the Rosetta Stone (E22)
- my paperback copy of Crime & Punishment (E22) (fictitious)
- the computer disk at ICS-FORTHthat stores the canonical Definition of the CIDOC CRM v.3.2 (E22)
- my empty DVD disk (E22) (fictitious)

In First Order Logic:

$$E24(x) \supset E18(x)$$
$$E24(x) \supset E71(x)$$

Properties:

P62 depicts (is depicted by): E1 CRM Entity
    (P62.1 mode of depiction: E55 Type)
P65 shows visual item (is shown by): E36 Visual Item

E22 Human-Made Object (CEO's HW)

E22 Human-Made Object
Subclass of: E19 Physical Object
               E24 Physical Human-Made Thing

Scope note: This class comprises all persistent physical objects of any size that are purposely created by human activity and have physical boundaries that separate them completely in an objective way from other objects.

               The class also includes all aggregates of objects made for functional purposes of whatever kind, independent of physical coherence, such as a set of chessmen.

Examples:
- Mallard (the World's fastest steam engine) (Solomon, 2003)
- the Portland Vase (Walker, 2004)
- the Coliseum (Hopkins, 2005)

In First Order Logic:

$$E22(x) \supset E19(x)$$
$$E22(x) \supset E24(x)$$

E25 Human-Made Feature (CEO's HW)

Subclass of: E24 Physical Human-Made Thing
E26 Physical Feature

Scope Note: This class comprises physical features that are purposely created by human activity, such as scratches, artificial caves, artificial water channels, etc. In particular, it includes the information encoding features on mechanical or digital carriers.

Examples:

- the Manchester Ship Canal (Famie, 1980)
- Michael Jackson's nose following plastic surgery
- The laser-readable "pits" engraved June 2014 on Martin Doerr's CD-R, copying songs of Edith Piaf's.
- The carved letters on the Rosetta Stone

In First Order Logic:

$$E25(x) \supset E24(x)$$
$$E25(x) \supset E26(x)$$

Issue 426 –Scope note for Pxxx holds or supports HW by RS:

This is **NOT** the final version. For the final version see [below](#)

P198 holds or supports

Domain: E18 Physical Thing
Range: E18 Physical Thing
Superproperty of:
Quantification: many to many

Scope Note: This property relates one instance of E18 Physical Thing which acts as a container or support for another instance of E18 Physical Thing. Typical examples of containers or supports include shelves, folders or boxes that provide a surface upon which is intended for other physical objects to be placed for storage, display, transport or other functions. Pxxx holds or supports is a shortcut of the more fully developed path from the domain E18 Physical Thing through P59 has section, E53 Place, P53i is former or current location of, to the range E18 Physical Thing. It is not a sub-property of P46 is composed of, as the held or supported object is not a component of the container or support.

This property can be used to avoid explicitly instantiating the E53 Place which is defined by an instance of E18 Physical Thing, especially when the only intended use of that instance of E18 Physical Thing is to act as a container or surface for the storage of other instances of E18 Physical Thing. The place's existence is defined by the existence of the container or surface, and will go out of existence at the same time as the Destruction of the container or surface.

Examples:

- archival folder "6" (E22) *holds or supports* the piece of paper (E22) carrying the text of a letter from Alloway to Sleigh
- artist's materials box "VG6" (E22) *holds or supports* Van Gogh's paintbrush 23 (E22)
- storage box "VG" (E22) *holds or supports* the artist's materials box "VG6" (E22)

- bronze coin bank "72.AC.99" (E22) *holds or supports* silver coin "72.AC.99-1" (E22)
- bookshelf "GRI-708.1" (E22) *holds or supports* the book "Catalog of Paintings in the J.Paul Gerry Museum" (E22)

The final version of the property

P198 holds or supports

Domain: E18 Physical Thing
Range: E18 Physical Thing
Quantification: one to many

Scope Note: This property relates one instance of E18 Physical Thing which acts as a container or support to a supported or contained instance of E18 Physical Thing. Typical examples of E18 Physical Things which are intended to function as a container or support include shelves, folders or boxes. These containers or supports provide a stable surface which is intended for other physical objects to be placed upon for storage, display, transport or other similar functions. *P198 holds or supports* is a shortcut of the more fully developed path from the domain E18 Physical Thing through *P59 has section*, E53 Place, *P53i is former or current location* of, to the range E18 Physical Thing. It is not a sub-property of P46 is composed of, as the held or supported object is not a component of the container or support.

This property can be used to avoid explicitly instantiating the E53 Place which is defined by an instance of E18 Physical Thing, especially when the only intended use of that instance of E18 Physical Thing is to act as a container or surface for the storage of other instances of E18 Physical Thing. The place's existence is defined by the existence of the container or surface, and will go out of existence at the same time as the Destruction of the container or surface. This property is transitive.

Examples

- Archival folder "1" (E22) *holds or supports* the piece of paper (E22) carrying the text of a letter from Alloway to Sleigh written in 1953
- Archival box "6" (E22) *holds or supports* the archival folder "1" (E22)
- Bookshelf "GRI.L2.c.1" (E22 *holds or supports* the copy "N582.M25 A627 2015" of the book titled "The J. Paul Getty Museum handbook of the collection" (E22)

In First Order Logic:
        P198(x,y) ⇒E18(x)
        P198(x,y) ⇒ E18(y)
        P198(x,y) ⇐ (∃z) [E53(z) ^ P59(x,z) ^ P53i(z,y)]

Issue 428

HW by CEO's HW (as edited over the meeting)

This is not the final form; **HW** for MD (see)

E59 Primitive Value

Subclass of: E1 CRM Entity
Superclass of: E60 Number

E61 Time Primitive
E62 String
E94 Space Primitive
E95 Spacetime Primitive

Scope Note: This class comprises values of primitive data types of programming languages or database management systems and data types composed of such values used as documentation elements, as well as their mathematical abstractions.

The instances of E59 Primitive Value and its subclasses are not considered elements of the universe of discourse the CIDOC CRM aims to define and analyze. Rather, they play the role of a symbolic interface between the scope of the model and the world of mathematical and computational manipulations and the symbolic objects they define and handle.

In particular they comprise lexical forms encoded as "strings" or series of characters and symbols based on encoding schemes (characterised by being a limited subset of the respective mathematical abstractions) such as UNICODE and values of datatypes that can be encoded in a lexical form, including quantitative specifications of time-spans and geometry. They have in common that instances of E59 Primitive Value define themselves by virtue of their encoded value, regardless of the nature of their mathematical abstractions.

Therefore, they must not be represented in an implementation, by a universal identifier, associated with a content model of different identity. In a concrete application, it is recommended that the primitive value system from a chosen implementation platform and/or data definition language be used to substitute for this class and its subclasses.

Examples:
- ABCDEFG (E62)
- 3.14 (E60)
- 0
- 1921-01-01 (E61)

In First Order Logic:
    E59(x) ⊃ E1(x)

The final version of E59 Primitive Value

E59 Primitive Value
Subclass of: E1 CRM Entity
Superclass of: E60 Number
                 E61 Time Primitive
                 E62 String
                 E94 Space Primitive
                 E95 Spacetime Primitive

Scope Note: This class comprises values of primitive data types of programming languages or database management systems and data types composed of such values used as documentation elements, as well as their mathematical abstractions.

The instances of E59 Primitive Value and its subclasses are not considered elements of the universe of discourse the CIDOC CRM aims to define and analyze. Rather, they play the role of a

symbolic interface between the scope of the model and the world of mathematical and computational manipulations and the symbolic objects they define and handle.

In particular they comprise lexical forms encoded as "strings" or series of characters and symbols based on encoding schemes (characterised by being a limited subset of the respective mathematical abstractions) such as UNICODE and values of datatypes that can be encoded in a lexical form, including quantitative specifications of time-spans and geometry. They have in common that instances of E59 Primitive Value define themselves by virtue of their encoded value, regardless of the nature of their mathematical abstractions.

Therefore, in an implementation, instances of E59 Primitive should be represented directly in the encoded symbolic form supported by the respective platform, such as a character string or a formatted date. They should they must not be represented in an implementation indirectly via, another a universal resource identifier, which in turn is linked to the actual encoded symbolic form. In a concrete application, it is recommended that the primitive value system from a chosen implementation platform and/or data definition language be used to substitute for this class and its subclasses.

Examples:

- ABCDEFG (E62)
- 3.14 (E60)
- 0
- 1921-01-01 (E61)

In First Order Logic:

$E59(x) \supset E1(x)$

Issue 450

Proposal to change the scope note of E54 Dimension –**HW** by MD: changes marked in **blue.** The SIG accepted the changes and assigned **SS** to edit the text for grammar. The version marked as "NEW" is not the final one. **For the final version see below**:

The issue closed

Old scope note

E54 Dimension

Subclass of: E1 CRM Entity
Superclass of: E97 Monetary Amount

Scope note: This class comprises quantifiable properties that can be measured by some calibrated means and can be approximated by values, i.e. points or regions in a mathematical or conceptual space, such as natural or real numbers, RGB values etc.

An instance of E54 Dimension represents the true quantity, independent from its numerical approximation, e.g. in inches or in cm. The properties of the class E54 Dimension allow for expressing the numerical approximation of the values of instances of E54 Dimension. If the true values belong to a non-discrete space, such as spatial distances, it is recommended to record them as approximations by intervals or regions of indeterminacy enclosing the assumed true values. For instance, a length of 5 cm may be recorded as 4.5-5.5 cm, according to the precision of the respective observation. Note, that interoperability of values described in different units depends critically on the representation as value regions.

Numerical approximations in archaic instances of E58 Measurement Unit used in historical records should be preserved. Equivalents corresponding to current knowledge should be recorded as additional instances of E54 Dimension as appropriate.

Examples:
- The 250 metric ton weight of the Luxor Obelisk
- The 5.17 m height of the statue of David by Michaelangelo
- The 530.2 carats of the Great Star of Africa diamond
- The AD1262-1312, 1303-1384 calibrated C14 date for the Shroud of Turin
- The 33 m diameter of the Stonehenge Sarcen Circle
- The 755.9 foot length of the sides of the Great Pyramid at Giza
- Christies' hammer price for "Vase with Fifteen Sunflowers" (E97) has currency British Pounds (E98)
- The time span of the Battle of Issos 333 B.C.E. (E52) had duration Battle of Issos duration (E54)

In First Order Logic:

$$E54(x) \supset E1(x)$$

Properties:

P90 has value: E60 Number
P91 has unit (is unit of): E58 Measurement Unit

New scope note

E54 Dimension
Subclass of: E1 CRM Entity
Superclass of: E97 Monetary Amount

Scope note: This class comprises quantifiable properties that can be measured by some calibrated means and can be approximated by values, i.e. points or regions in a mathematical or conceptual space, such as natural or real numbers, RGB values etc.

An instance of E54 Dimension represents the empirical or theoretically derived quantity, including the precision tolerances resulting from the particular method or calculation. The identity of an instance of E54 Dimension depends on the method of its determination because it may provide different values even for comparable quantities. For instance, the wingspan of a bird alive or dead is a different dimension. The method of determination should be expressed using the property P2 has type (is type of). Note that simple terms such as "diameter" or "length" are normally insufficient to unambiguously describe a respective dimension. In contrast, "maximum linear extent" may be sufficient.

The properties of the class E54 Dimension allow for expressing the numerical approximation of the values of instances of E54 Dimension adequate to the precision of the applied method of determination. If the respective quantity belongs to a non-discrete space according to the laws of physics, such as spatial distances, it is recommended to record them as approximations by intervals or regions of indeterminacy enclosing the assumed true values. For instance, a length of 5 cm may be recorded as 4.5-5.5 cm, according to the precision of the respective observation. Note, that comparability of values described in different units depends critically on the representation as value regions.

Numerical approximations in archaic instances of E58 Measurement Unit used in historical records should be preserved. Equivalents corresponding to current knowledge should be recorded as additional instances of E54 Dimension, as appropriate.

Examples:

- The 250 metric ton weight of the Luxor Obelisk
- The 5.17 m vertical height of the statue of David by Michaelangelo
- The 530.2 carats of the Great Star of Africa diamond
- The AD1262-1312, 1303-1384 calibrated C14 date for the Shroud of Turin
- The 33 m horizontal diameter of the Stonehenge Sarcen Circle
- The 755.9 foot length of the sides of the Great Pyramid at Giza
- Christies' hammer price for "Vase with Fifteen Sunflowers" in British Pounds (E97)
- The duration of the time span of the Battle of Issos 333 B.C.E.

In First Order Logic:

$$E54(x) \supset E1(x)$$

Properties:

P90 has value: E60 Number
P91 has unit (is unit of): E58 Measurement Unit

Final Version [HW by SS]

The finalized version of the scope note of E54 Dimension, as updated by SS

E54 Dimension

Subclass of: E1 CRM Entity
Superclass of: E97 Monetary Amount

Scope note: This class comprises quantifiable properties that can be measured by some calibrated means and can be approximated by values, i.e. by points or regions in a mathematical or conceptual space, such as natural or real numbers, RGB values etc.

An instance of E54 Dimension represents the empirical or theoretically derived quantity, including the precision tolerances resulting from the particular method or calculation. The identity of an instance of E54 Dimension depends on the method of its determination because each method may produce different values even when determining comparable qualities. For instance, the wingspan of a bird alive or dead is a different dimension. Thermoluninescence dating and Rehydroxylation [RHX] dating are different dimensions of temporal distance from now, even if they aim at dating the same object. The method of determination should be expressed using the property P2 has type (is type of). Note that simple terms such as "diameter" or "length" are normally insufficient to unambiguously describe a respective dimension. In contrast, "maximum linear extent" may be sufficient.

The properties of the class E54 Dimension allow for expressing the numerical approximation of the values of instances of E54 Dimension adequate to the precision of the applied method of determination. If the respective quantity belongs to a non-discrete space according to the laws of physics, such as spatial distances, it is recommended to record them as approximations by intervals or regions of indeterminacy enclosing the assumed true values. For instance, a length of 5 cm may be recorded as 4.5-5.5 cm, according to the precision of the respective observation. Note, that comparability of values described in different units depends critically on the representation as value regions.

Numerical approximations in archaic instances of E58 Measurement Unit used in historical records should be preserved. Equivalents corresponding to current knowledge should be recorded as additional instances of E54 Dimension, as appropriate.

Examples:

- The weight of the Luxor Obelisk [250 metric tons]
- The vertical height of the statue of David by Michaelangelo [5.17 metres]
- The weight of the Great Star of Africa diamond [530.2 carats]
- The calibrated C14 date for the Shroud of Turin [AD1262-1312, 1303-1384]
- The horizontal diameter of the Stonehenge Sarcen Circle [33 metres]
- The length of the sides of the Great Pyramid at Giza [755.9 feet]
- Christie's hammer price for "Vase with Fifteen Sunflowers" in British Pounds (E97)
- The duration of the time span of the Battle of Issos [333 B.C.E.]

In First Order Logic:

$$E54(x) \supset E1(x)$$

Properties:

P90 has value: E60 Number
P91 has unit (is unit of): E58 Measurement Unit

Issue 453

Changes in **blue**

P4 has time-span (is time-span of) edited form

Domain: E2 Temporal Entity
Range: E52 Time-Span
Quantification: many to one, necessary (1,1:0,n)

Scope note: This property associates an instance of E2 Temporal Entity with the instance of E52 Time-Span during which it was on-going. The associated instance of E52 Time-Span is understood as the real time-span during which the phenomena making up the temporal entity instance were active. More than one instance of E2 Temporal Entity may share a common instance of E52 Time-Span only if they come into being and end being due to identical declarations or events.

Examples:

- the Yalta Conference (E7) has time-span Yalta Conference time-span (E52)

In First Order Logic:

$$P4(x,y) \supset E2(x)$$
$$P4(x,y) \supset E52(y)$$

P170 defines time (time is defined by) –HW by SS

Domain: E61Time Primitive
Range: E52 Time Span
Quantification: many to one (0,1:0,n)

Scope note: This property associates an instance of E61 Time Primitive with the instance of E52 Time-Span that constitutes the interpretation of the terms of the time primitive as an extent in absolute, real time.

The quantification allows several instances of E61 Time Primitive that are each expressed in different syntactic forms, to define the same instance of E52 Time Span.

Examples:

- (1800/1/1 0:00:00 – 1899/31/12 23:59:59)(E61) defines time The 19th century (E52)
- (1968/1/1 – 2018/1/1)(E61) defines time "1968/1/1 – 2018/1/1" (E52) [an arbitrary time-span during which the Saint Titus reliquary was present in the Saint Titus Church in Heraklion, Crete]

In First Order Logic:

$$P170(x,y) \supset E61(x)$$
$$P170(x,y) \supset E52(y)$$

Issue 458

Changes marked in **blue**

P79 beginning is qualified by

(edited by SS, discussed, and accepted over the 47th CIDOC CRM SIG meeting)

Scope note: This property associates an instance of E52 Time-Span with a note detailing the scholarly or scientific opinions and justifications about the certainty, precision, sources etc of its beginning. Such notes may also be used to elaborate arguments about constraints or to give explanations of alternatives.

P80 end is qualified by

(edited by SS, discussed, and accepted at the 47th CIDOC CRM SIG meeting)

Scope note: This property associates an instance of E52 Time-Span with a note detailing the scholarly or scientific opinions and justifications about the end of this time-span concerning certainty, precision, sources etc. This property may also be used to describe arguments constraining possible dates and to distinguish reasons for alternative dates.

P81 ongoing throughout

Scope note: This property associates an instance of E52 Time-Span with an instance of E61 Time Primitive specifying a minimum period of time covered by it. Since Time-Spans may not have precisely known temporal extents, the CIDOC CRM supports statements about the minimum and maximum temporal extents of Time-Spans. This property allows a Time-Span's minimum temporal extent (i.e. its inner boundary) to be assigned an E61 Time Primitive value. Time Primitives are treated by the CIDOC CRM as application or system specific date intervals, and are not further analysed. If different sources of evidence justify different minimum extents without contradicting each other, the smallest interval including all these extents will be the best estimate. This should be taken into account for information integration.

P82 at some time within

Scope note: This property describes the maximum period of time within which an E52 Time-Span falls. Since Time-Spans may not have precisely known temporal extents, the CIDOC CRM supports statements about the minimum and maximum temporal extents of Time-Spans. This property allows a Time-Span's maximum temporal extent (i.e. its outer boundary) to be assigned an E61 Time Primitive value. Time Primitives are treated by the CIDOC CRM as application or system specific date intervals, and are not further analysed. If different sources of evidence justify different maximum extents without contradicting each other, the resulting intersection of all these extents will be the best estimate. This should be taken into account for information integration.

Issue 462

Definition of P90 has value following the deprecation of P181 has amount. Changes marked in **blue**

P90 has value

Domain: E54 Dimension
Range: E60 Number
~~Superproperty of: E97 Monetary Amount. P181 has amount: E60 Number~~
Quantification: many to one, necessary (1,1:0,n)

Scope note: This property allows an instance of E54 Dimension to be approximated by an instance of E60 Number primitive.

Examples:

- height of silver cup 232 (E54) *has value* 226 (E60)
- Christie's hammer price for "Vase with Fifteen Sunflowers" (E97) has value 24,750,000 (E60)

In First Order Logic:

$$P90(x,y) \Rightarrow E54(x)$$
$$P90(x,y) \Rightarrow E60(y)$$

Issue 463

Proposal to change the scope note of E37 Mark –HW by MD: changes marked in **blue.**

The sig decided to introduce it to 7.0.1. The issue is closed.

OLD Scope Note

E37 Mark

Subclass of: E36 Visual Item
Superclass of: E34 Inscription

Scope note: This class comprises symbols, signs, signatures or short texts applied to instances of E24 Physical Human-Made Thing by arbitrary techniques in order to indicate the creator, owner, dedications, purpose, etc.

This class specifically excludes features that have no semantic significance, such as scratches or tool marks. These should be documented as instances of E25 Human-Made Feature.

Examples:

- Minoan double axe mark (Lowe Fri, 2011)
- ©
- ☺

In First Order Logic:

$$E37(x) \supset E36(x)$$

NEW Scope Note

E37 Mark

Subclass of: E36 Visual Item
Superclass of: E34 Inscription

Scope note: **This class comprises symbols, signs, signatures or short texts applied to instances of E24 Physical Human-Made Thing by arbitrary techniques, often in order to indicate**

such things as creator, owner, dedications, purpose or to communicate information generally. Instances of E37 Mark do not represent the actual image of a mark, but the abstract ideal (or archetype) as used for codification in reference documents forming cultural documentation.

This class specifically excludes features that have no semantic significance, such as scratches or tool marks. These should be documented as instances of E25 Human-Made Feature.

Examples:
- Minoan double axe mark (Lowe Fri, 2011)
- ©
- ☺

In First Order Logic:

E37(x) ⇒ E36(x)

Issue 475 –HW by RS: New scope note for E10 Transfer of Custody – feedback incorporated.

Changes marked in blue

OLD scope note

E10 Transfer of Custody

Subclass of: E7 Activity

Scope note: This class comprises transfers of physical custody of objects between instances of E39 Actor. The recording of the donor and/or recipient is optional. It is possible that in an instance of E10 Transfer of Custody there is either no donor or no recipient. Depending on the circumstances it may describe:

1. the beginning of custody
2. the end of custody
3. the transfer of custody
4. the receipt of custody from an unknown source
5. the declared loss of an object

The distinction between the legal responsibility for custody and the actual physical possession of the object should be expressed using the property P2 has type (is type of). A specific case of transfer of custody is theft. The sense of physical possession requires that the object of custody is in the hands of the keeper at least with a part representative for the whole. The way, in which a representative part is defined, should ensure that it is unambiguous who keeps a part and who the whole and should be consistent with the identity criteria of the kept instance of E18 Physical Thing. For instance, in the case of a set of cutlery we may require the majority of pieces having been in the hands of the actor regardless which individual pieces are kept over time.

The interpretation of the museum notion of "accession" differs between institutions. The CIDOC CRM therefore models legal ownership and physical custody separately. Institutions will then model their specific notions of accession and deaccession as combinations of these.

Examples:
- the delivery of the paintings by Secure Deliveries Inc. to the National Gallery the return of Picasso's "Guernica" to Madrid's Prado in 1981 (Chipp, 1988)

In First Order Logic:

$E10(x) \supset E7(x)$

Properties:

P28 custody surrendered by (surrendered custody through): E39 Actor
P29 custody received by (received custody through): E39 Actor
P30 transferred custody of (custody transferred through): E18 Physical Thing

NEW scope note

E10 Transfer of Custody

Subclass of: E7 Activity

Scope note: This class comprises transfers of the physical custody, or the legal responsibility for the physical custody, of objects. The recording of the donor or recipient is optional. It is possible that in an instance of E10 Transfer of Custody there is either no donor or no recipient. Depending on the circumstances it may describe:

1. the beginning of custody (there is no previous custodian)
2. the end of custody (there is no subsequent custodian)
3. the transfer of custody (transfer from one custodian to the next)
4. the receipt of custody from an unknown source (the previous custodian is unknown)
5. the declared loss of an object (the current or subsequent custodian is unknown)

In the event that only a single kind of transfer of custody, either the legal responsibility for the custody or the actual physical possession of the object but not both, this difference should be expressed using the property P2 has type (is type of). A specific case of transfer of custody is theft. The sense of physical possession requires that the object of custody is in the hands of the keeper at least with a part representative for the whole. The way, in which a representative part is defined, should ensure that it is unambiguous who keeps a part and who the whole and should be consistent with the identity criteria of the kept instance of E18 Physical Thing. For instance, in the case of a set of cutlery we may require the majority of pieces having been in the hands of the actor regardless which individual pieces are kept over time.

The interpretation of the museum notion of "accession" differs between institutions. The CIDOC CRM therefore models legal ownership and physical custody separately. Institutions will then model their specific notions of accession and deaccession as combinations of these.

Examples:

- the delivery of the paintings by Secure Deliveries Inc. to the National Gallery the return of Picasso's "Guernica" to Madrid's Prado in 1981 (Chipp, 1988)

In First Order Logic:

$E10(x) \Rightarrow E7(x)$

Properties:

P28 custody surrendered by (surrendered custody through): E39 Actor
P29 custody received by (received custody through): E39 Actor
P30 transferred custody of (custody transferred through): E18 Physical Thing

Issue 483

the scope note of E33 Linguistic Object –HW by MD.

The changes are marked in **blue**.

OLD scope note

E33 Linguistic Object

Subclass of: E73 Information Object

Superclass of: E34 Inscription
                          E35 Title

Scope note: This class comprises identifiable expressions in natural language or languages.

Instances of E33 Linguistic Object can be expressed in many ways: e.g. as written texts, recorded speech or sign language. However, the CIDOC CRM treats instances of E33 Linguistic Object independently from the medium or method by which they are expressed. Expressions in formal languages, such as computer code or mathematical formulae, are not treated as instances of E33 Linguistic Object by the CIDOC CRM. These should be modelled as instances of E73 Information Object.

The text (in a wider sense) of an instance of E33 Linguistic Object can be documented in a note by P3 has note: E62 String

Examples:
- the text of the Ellesmere Chaucer manuscript (Hilmo, 2004)
- the lyrics of the song "Blue Suede Shoes" (Cooper, 2008)
- the text of the Jabberwocky by Lewis Carroll (Carroll, 1981)
- the text of "Doktoro Jekyll kaj Sinjoro Hyde" (an Esperanto translation of Dr Jekyll and Mr Hyde). (Stevenson, 1909)

In First Order Logic:

$$E33(x) \supset E73(x)$$

Properties:

P72 has language (is language of): E56 Language

P73 has translation (is translation of): E33 Linguistic Object

NEW scope note

E33 Linguistic Object

Subclass of: E73 Information Object

Superclass of: E34 Inscription
                          E35 Title

Scope note: This class comprises identifiable expressions in natural language or languages.

Instances of E33 Linguistic Object can be expressed in many ways: e.g. as written texts, recorded speech or sign language. However, the CIDOC CRM treats instances of E33 Linguistic Object

independently from the medium or method by which they are expressed. Expressions in formal languages, such as computer code or mathematical formulae, are not treated as instances of E33 Linguistic Object by the CIDOC CRM. These should be modelled as instances of E73 Information Object.

In general, an instance of E33 Linguistic Object may also contain non-linguistic information, often of artistic or aesthetic value. Only in cases in which the content of an instance of E33 Linguistic Object can completely be expressed by a series of binary-encoded symbols, its content may be documented within a respective knowledge base by the property P190 has symbolic content: E62 String. Otherwise, it should be understood as an identifiable digital resource only available independently from the respective knowledge base.

In other cases, such as pages of an illuminated manuscript or recordings containing speech in a language supported by a writing system, the linguistic part of the content of an instance of E33 Linguistic Object may be documented within a respective knowledge base in a note by P3 has note: E62 String. Otherwise, it may be described using the property P165 incorporates (is incorporated in): E73 Information Object as a different object with its own identity.

Examples:

- the text of the Ellesmere Chaucer manuscript (Hilmo, 2004)
- the lyrics of the song "Blue Suede Shoes" (Cooper, 2008)
- the text of the Jabberwocky by Lewis Carroll (Carroll, 1981)
- the text of "Doktoro Jekyll kaj Sinjoro Hyde" [an Esperanto translation of Dr Jekyll and Mr Hyde]. (Stevenson, 1909)

In First Order Logic:

$$E33(x) \supset E73(x)$$

Properties:

> P72 has language (is language of): E56 Language
> P73 has translation (is translation of): E33 Linguistic Object

Transitivity: decision 26/05/2020

DECISION: Transitive properties should be marked as such, intransitive not so much (unless their domain and range are identical-in which case, it should be explicitly noted when they are not transitive)

The list of affected properties follows: (those marked with green comment are ok as they are. The ones with yellow comments needs adjustment of the scope note).

E3 Condition State. P5 consists of (forms part of):E3 Condition State	Transitive ok, marked in text
E4 Period. P9 consists of (forms part of):E4 Period	Transitive ok, marked in text
E92 Spacetime Volume. P10 falls within (contains):E92 Spacetime Volume	Transitive ok, marked in text
E18 Physical Thing. P46 is composed of (forms part of):E18 Physical Thing	Transitive ok, marked in text
P69 has association with (is associated with)	Transitive ok, add 'This property is transitive.' in the scope note is not transitive, added in 7.0
E33 Linguistic Object: P73 has translation:E33 Linguistic Object	Transitive ok, marked in text
E52 Time-Span. P86 falls within (contains):E52 Time-Span	Transitive ok, marked in text

E53 Place. P89 falls within (contains):E53 Place	Transitive ok, marked in text
E90 Symbolic Object.P106 is composed of (forms part of):E90 Symbolic Object	Transitive ok, marked in text
E53 Place.P122 borders with:E53 Place	Is not transitive, add 'This property is not transitive' in the scope note.
E55 Type. P127 has broader term (has narrower term):E55 Type	Transitive ok, marked in text
E70 Thing.P130 shows features of (features are also found on):E70 Thing	Is not transitive, add 'This property is not transitive' in the scope note.
E92 Spacetime Volume.P133 is separated from:E92 Spacetime Volume	Is not transitive, add 'This property is not transitive' in the scope note.
E7 Activity. P134 continued (was continued by):E7 Activity	Is not transitive, add 'This property is not transitive' in the scope note.
E41 Appellation. P139 has alternative form:E41 Appellation	Is not transitive and is marked as such in the text. NB: Equivalence as a relational operator is transitive, consider change: "The equivalence applies to all cases of use of an instance of E41 Appellation."
E89 Propositional Object. P148 has component (is component of):E89 Propositional Object	Transitive ok, marked in text
E55 Type. P150 defines typical parts of (defines typical wholes for):E55 Type	Is not transitive, adjust text, delete in general 'This property is in general not transitive' in the scope note. A property is transitive or not transitive for the selected domain and range (in case of subclasses)
E21 Person. P152 has parent(is parent of):E21 Person	Is not transitive, adjust text, delete in general 'This property is in general not transitive' in the scope note. A property is transitive or not transitive for the selected domain and range (in case of subclasses)
E2 Temporal Entity. P174 starts before the end of (ends after the start of):E2 Temporal Entity	Is not transitive, add 'This property is not transitive' in the scope note.
E2 Temporal Entity. P175 starts before or with the start of (starts after or with the start of):E2 Temporal Entity	In a model with fuzzy borders, this property will not be transitive.
E2 Temporal Entity. P176 starts before the start of (starts after the start of): E2 Temporal Entity	Transitive ok, add 'This property is transitive.' in the scope note
E2 Temporal Entity. P182 ends before or at the start of (starts after or with the end of): E2 Temporal Entity	In a model with fuzzy borders, this property will not be transitive
E2 Temporal Entity. P183 ends before the start of (starts after the end of): E2 Temporal Entity	Transitive ok, add 'This property is transitive.' in the scope note
E2 Temporal Entity. P184 ends before or with the end of (ends with or after the end of): E2 Temporal Entity	In a model with fuzzy borders, this property will not be transitive.
E2 Temporal Entity. P185 ends before the end of (ends after the end of): E2 Temporal Entity	Transitive ok, add 'This property is transitive.' in the scope note
E53 Place. P189 approximates :E53 Place	Is not transitive, add 'This property is not transitive' in the scope note.

The discussion and the HW by CEO & MD can be found

https://drive.google.com/file/d/1LvwM8d_pgYDHv6e4faDrRhpEZJ7JJTuf/view?usp=sharing

P139 has alternative form –HW by MD.

P139 has alternative form

Domain: E41 Appellation
Range: E41 Appellation
Quantification: many to many (0,n:0,n)

Scope note: This property establishes a relationship of equivalence between two instances of E41 Appellation independent from any item identified by them. It is a dynamic asymmetric relationship, where the range expresses the derivative, if such a direction can be established. Otherwise, the relationship is symmetric. The relationship is not transitive.

The equivalence applies to all cases of use of an instance of E41 Appellation. Multiple names assigned to an object, which are not equivalent for all things identified with a specific instance of E41 Appellation, should be modelled as repeated values of *P1 is identified by (identifies)*.

P139.1 has type allows the type of derivation, such as "transliteration from Latin 1 to ASCII" be refined.

Examples:
- "Martin Doerr" (E41) *has alternative form* "Martin Dörr" (E41) *has type* Alternate spelling (E55)
- "Гончарова, Наталья Сергеевна" (E41) *has alternative form* "Gončarova, Natal´â Sergeevna" (E41) *has type* ISO 9:1995 transliteration (E55)
- "Αθήνα" has alternative form "Athina" has type transcription.

NEW scope note

P139 has alternative form

Domain: E41 Appellation
Range: E41 Appellation
Quantification: many to many (0,n:0,n)

Scope note: This property associates an instance of E41 Appellation with another instance of E41 Appellation that constitutes a derivative or variant of the former and that may also be used for identifying items identified by the former, in suitable contexts, independent from the particular item to be identified. This property should not be confused with additional variants of names used characteristically for a single, particular item, such as individual nicknames. It is a dynamic asymmetric relationship, where the range expresses the derivative, if such a direction can be established. Otherwise, the relationship is symmetric. The relationship is not transitive.

Multiple names assigned to an object, which do not apply to all things identified with the specific instance of E41 Appellation, should be modelled as repeated values of *P1 is identified by (identifies)* of this object.

P139.1 has type allows the type of derivation, such as "transliteration from Latin 1 to ASCII" be refined.

Examples:

- "Martin Doerr" (E41) *has alternative form* "Martin Dörr" (E41) *has type* Alternate spelling (E55)

- "Гончарова, Наталья Сергеевна" (E41) *has alternative form* "Gončarova, Natal´â Sergeevna" (E41) *has type* ISO 9:1995 transliteration (E55)
- "Αθήνα" has alternative form "Athina" has type transcription.

adding examples to P102 has title

Old Example:

- the first book of the Old Testament (E33) *has title* "Genesis" (E35)
  has type title (E55)

Edited Example:

- the first book of the Old Testament (E33) has title "Genesis" (E35)
  has type translated title (E55)

New Examples:

- Monet's painting from 1868-1869 held by Musée d'Orsay, Paris, under inventory number RF 1984 164 (E24) has title "La Pie" (E35)
  has type creator's title (E55)
- Monet's painting from 1868-1869 held by Musée d'Orsay, Paris, under inventory number RF 1984 164 (E24) has title "The Magpie" (E35)
  has type translated title (E55)

P121 overlaps with & P122 borders with; edit the scope notes –HW by MD

P121 overlaps with

The changes from v6.2.9 are marked in **blue**:

OLD scope note

P121 overlaps with

Domain: E53 Place
Range: E53 Place
Quantification: many to many (0,n:0,n)

Scope note: This symmetric property associates an instance of E53 Place with another instance of E53 Place geometrically overlapping it.

It does not specify anything about the shared area. This property is purely spatial, in contrast to the temporal overlaps described by pxxx, pxxy or pxxz, and and, spatio temporal overlaps described by p132 spatiotemporally overlaps with.

Examples:

- the territory of the United States (E53) overlaps with the Arctic (E53)
- The maximal extent of the Greek Kingdom (E53) overlaps with the maximal extent of the Ottoman Empire(E53)

In First Order Logic:

$$P121(x,y) \supset E53(x)$$
$$P121(x,y) \supset E53(y)$$

$$P121(x,y) \supset P121(y,x)$$

The changes from v6.2.9 are marked in **blue**:

P121 overlaps with

Domain: E53 Place
Range: E53 Place
Quantification: many to many (0,n:0,n)

Scope note: This symmetric property associates an instance of E53 Place with another instance of E53 Place geometrically overlapping it.

It does not specify anything about the shared area. This property is purely spatial. It does not imply that phenomena that define, by their extent, places related by P121 overlaps with have ever covered a common area at the same time or even coexisted. In contrast, spatiotemporal overlaps described by P132 spatiotemporally overlaps are the total of areas simultaneously covered by the related spacetime volumes.

Examples:

- the territory of the United States (E53) *overlaps with* the Arctic (E53)
- the maximal extent of the Kingdom of Greece (1832-1973) (E53) *overlaps with* the maximal extent of the Republic of Turkey (29 October 1923 to now) (E53)

In First Order Logic:

$$P121(x,y) \Rightarrow E53(x)$$
$$P121(x,y) \Rightarrow E53(y)$$
$$P121(x,y) \Rightarrow P121(y,x)$$

P122 borders with

P122 borders with
Domain: E53 Place
Range: E53 Place
Quantification: many to many (0,n:0,n)

Scope note: This symmetric property associates an instance of E53 Place with another instance of E53 Place which shares a part of its borders.

This property is purely spatial, in contrast to time properties, which are purely temporal.

Examples:

- Scotland (E53) *borders with* England (E53)

In First Order Logic:

$$P122(x,y) \supset E53(x)$$
$$P122(x,y) \supset E53(y)$$
$$P122(x,y) \supset P121(y,x)$$

P122 borders with

Domain: E53 Place
Range: E53 Place
Quantification: many to many (0,n:0,n)

Scope note: This symmetric property associates an instance of E53 Place with another instance of E53 Place which shares a part of its border.

This property is purely spatial. It does not imply that the phenomena that define, by their extent, places related by P122 borders with have ever shared a respective border at the same time or even coexisted. In particular, this may be the case when the respective common border is formed by a natural feature.
This property is not transitive

Examples:
- Scotland (E53) *borders with* England (E53)

In First Order Logic:
P122(x,y) ⇒ E53(x)
P122(x,y) ⇒ E53(y)
P122(x,y) ⇒ P122(y,x)

Issue 497

P164 is temporally specified by (temporally specifies) -**HW** by **MD** and online changes

P164 is temporally specified by (temporally specifies)
Domain: E93 Presence
Range: E52 Time-Span
Subproperty of: E92 Spacetime Volume.P160 has temporal projection: E52 Time-Span
Quantification: (1,1 :0,n)

Scope note: This property relates an instance of E93 Presence with the chosen instance of E52 Time-Span that defines the time-slice of the spacetime volume that this instance of E93 Presence is related to by the property P166 was a presence of (had presence).

The chosen instance of E52 Time-Span may be declared as a particular date range of historical interest, using the property P170 defines time (time is defined by). Alternatively, a time-span of different empirical origin may be referred to, such as the time-span of some instance of E2 Temporal Entity, as specified using P4 has time-span (is time-span of). The latter construct can be used to specify the whereabouts of some item having the nature of a spacetime volume within the temporal limits of the respective phenomenon. For instance, for describing the whereabouts of some person during a particular war period.

Examples:
- 2016-02-09 (E52) was time-span of the last day of the 2016 Carnival in Cologne (E93).
- Johann Joachim Winckelmann's whereabouts in December 1755 (E93) during December 1755 (E52)
- Johann Joachim Winkelmann's whereabouts from November 19 1755 until April 9 1768 (E93) during November 19 1755 until April 9 1768 (E52)

In First Order Logic:
P164 (x,y) ⇒ E93(x)
P164 (x,y) ⇒ E52(y)
P164 (x,y) ⇒ P160(x,y)

Appendix 3: HW for ISSUE 456 and ISSUE 459

Working documents for the issues 456 compatibility statement and 459 modelling principles.

The issues 456 and 459 are about the adjustment of text of the introduction to the CRM. In the copy of the introduction below, I have inserted small subsections (level 3) with comments. By opening the navigation pane it is easy to find the places in the text where the editorial team suggests alteration. Most are trivial.

Definition of the CIDOC Conceptual Reference Model

Introduction

This document is the formal definition of the **CIDOC Conceptual Reference Model ("CIDOC CRM"),** a formal ontology intended to facilitate the integration, mediation and interchange of heterogeneous cultural heritage information. The CIDOC CRM is the culmination of more than a decade of standards development work by the International Committee for Documentation (CIDOC) of the International Council of Museums (ICOM). Work on the CIDOC CRM itself began in 1996 under the auspices of the ICOM-CIDOC Documentation Standards Working Group. Since 2000, development of the CIDOC CRM has been officially delegated by ICOM-CIDOC to the CIDOC CRM Special Interest Group, which collaborates with the ISO working group ISO/TC46/SC4/WG9 to bring the CIDOC CRM to the form and status of an International Standard.

Objectives of the CIDOC CRM

The primary role of the CIDOC CRM is to enable information exchange and integration between heterogeneous sources of cultural heritage information. It aims at providing the semantic definitions and clarifications needed to transform disparate, localised information sources into a coherent global resource, be it within a larger institution, in intranets or on the Internet.

Its perspective is supra-institutional and abstracted from any specific local context. This goal determines the constructs and level of detail of the CIDOC CRM.

More specifically, it defines and is restricted to the **underlying semantics** of database schemata and document **structures** used in cultural heritage and museum documentation in terms of a formal ontology. It does **not** define any of the **terminology** appearing typically as data in the respective data structures; however it foresees the characteristic relationships for its use. It does **not** aim at proposing what cultural institutions **should** document. Rather it explains the logic of what they actually currently document, and thereby enables **semantic interoperability.**

It intends to provide a model of the intellectual structure of cultural documentation in logical terms. As such, it is not optimised for implementation-specific storage and processing aspects. Implementations may lead to solutions where elements and links between relevant elements of our conceptualizations are

no longer explicit in a database or other structured storage system. For instance the birth event that connects elements such as father, mother, birth date, birth place may not appear in the database, in order to save storage space or response time of the system. The CIDOC CRM allows us to explain how such apparently disparate entities are intellectually interconnected, and how the ability of the database to answer certain intellectual questions is affected by the omission of such elements and links.

The CIDOC CRM aims to support the following specific functionalities:

- Inform developers of information systems as a guide to good practice in conceptual modelling, in order to effectively structure and relate information assets of cultural documentation.
- Serve as a common language for domain experts and IT developers to formulate requirements and to agree on system functionalities with respect to the correct handling of cultural contents.
- To serve as a formal language for the identification of common information contents in different data formats; in particular to support the implementation of automatic data transformation algorithms from local to global data structures without loss of meaning. The latter being useful for data exchange, data migration from legacy systems, data information integration and mediation of heterogeneous sources.
- To support associative queries against integrated resources by providing a global model of the basic classes and their associations to formulate such queries.
- It is further believed, that advanced natural language algorithms and case-specific heuristics can take significant advantage of the CIDOC CRM to resolve free text information into a formal logical form, if that is regarded beneficial. The CIDOC CRM is however not thought to be a means to replace scholarly text, rich in meaning, by logical forms, but only a means to identify related data.

Users of the CIDOC CRM should be aware that the definition of data entry systems requires support of community-specific terminology, guidance to what should be documented and in which sequence, and application-specific consistency controls. The CIDOC CRM does not provide such notions.

By its very structure and formalism, the CIDOC CRM is extensible and users are encouraged to create extensions for the needs of more specialized communities and applications.

Scope of the CIDOC CRM

The overall scope of the CIDOC CRM can be summarised in simple terms as the curated knowledge of museums.

However, a more detailed and useful definition can be articulated by defining both the Intended Scope, a broad and maximally-inclusive definition of general application principles, and the Practical Scope, which is expressed by the overall scope of a reference set of specific identifiable museum documentation standards and practices that the CIDOC CRM aims to encompass, however restricted in its details to the limitations of the Intended Scope.

The Intended Scope of the CIDOC CRM may be defined as all information required for the exchange and integration of heterogeneous scientific documentation of museum collections. This definition requires further elaboration:

- The term "scientific documentation" is intended to convey the requirement that the depth and quality of descriptive information that can be handled by the CIDOC CRM should be sufficient for serious academic research. This does not mean that information intended for presentation to members of the general public is excluded, but rather that the CIDOC CRM is intended to provide the level of detail and precision expected and required by museum professionals and researchers in the field.
- The term "museum collections" is intended to cover all types of material collected and displayed by museums and related institutions, as defined by ICOM[2]. This includes collections, sites and monuments relating to fields such as social history, ethnography, archaeology, fine and applied arts, natural history, history of sciences and technology.
- The documentation of collections includes the detailed description of individual items within collections, groups of items and collections as a whole. The CIDOC CRM is specifically intended to cover contextual information: the historical, geographical and theoretical background that gives museum collections much of their cultural significance and value.
- The exchange of relevant information with libraries and archives, and the harmonisation of the CIDOC CRM with their models, falls within the Intended Scope of the CIDOC CRM.
- Information required solely for the administration and management of cultural institutions, such as information relating to personnel, accounting, and visitor statistics, falls outside the Intended Scope of the CIDOC CRM.

The Practical Scope[3] of the CIDOC CRM is expressed in terms of the current reference standards for museum documentation that have been used to guide and validate the CIDOC CRM's development. The CIDOC CRM covers the same domain of discourse as the union of these reference standards; this means that data correctly encoded according to these museum documentation standards there can be a CIDOC CRM-compatible expression that conveys the same meaning.

Terminology

The following definitions of key terminology used in this document are provided both as an aid to readers unfamiliar with object-oriented modelling terminology, and to specify the precise usage of terms that are sometimes applied inconsistently across the object oriented modelling community for the purpose of this document. Where applicable, the editors have tried to consistently use terminology that is compatible with that of the Resource Description Framework (RDF)[4], a recommendation of the World Wide Web Consortium. The editors have tried to find a language which is comprehensible to the non-

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[2] The ICOM Statutes provide a definition of the term "museum" at http://icom.museum/statutes.html#2

[3] The Practical Scope of the CIDOC CRYM, including a list of the relevant museum documentation standards, is discussed in more detail on the CIDOC CRYM website at http://cidoc.ics.forth.gr/scope.html

[4] Information about the Resource Description Framework (RDF) can be found at http://www.w3.org/RDF/

computer expert and precise enough for the computer expert so that both understand the intended meaning.

Class	A class is a category of items that share one or more common traits serving as criteria to identify the items belonging to the class. These **properties** need not be explicitly formulated in logical terms, but may be described in a text (here called a **scope note**) that refers to a common conceptualisation of domain experts. The sum of these traits is called the **intension** of the class. A class may be the **domain** or **range** of none, one or more properties formally defined in a model. The formally defined properties need not be part of the intension of their domains or ranges: such properties are optional. An item that belongs to a class is called an **instance** of this class. A class is associated with an open set of real life instances, known as the **extension** of the class. Here "open" is used in the sense that it is generally beyond our capabilities to know all instances of a class in the world and indeed that the future may bring new instances about at any time (**Open World**). Therefore a class cannot be defined by enumerating its instances. A class plays a role analogous to a grammatical noun, and can be completely defined without reference to any other construct (unlike properties**,** which must have an unambiguously defined domain and range). In some contexts, the terms individual class, entity or node are used synonymously with class.

For example:

Person is a class. To be a Person may actually be determined by DNA characteristics, but we all know what a Person is. A Person may have the property of being a member of a Group, but it is not necessary to be member of a Group in order to be a Person. We shall never know all Persons of the past. There will be more Persons in the future.

subclass	A subclass is a **class** that is a specialization of another class (its **superclass**). Specialization or the IsA relationship means that:

1. all **instances** of the subclass are also instances of its superclass,
2. the **intension** of the subclass extends the intension of its superclass, i.e. its traits are more restrictive than that of its superclass and
3. the subclass inherits the definition of all of the **properties** declared for its superclass without exceptions (**strict inheritance**), in addition to having none, one or more properties of its own.

A subclass can have more than one immediate superclass and consequently inherits the properties of all of its superclasses (**multiple inheritance**). The IsA relationship or specialization between two or more classes gives rise to a structure known as a class hierarchy. The IsA relationship is transitive and may

not be cyclic. In some contexts (e.g. the programming language C++) the term derived class is used synonymously with subclass.

For example:

Every Person IsA Biological Object, or Person is a subclass of Biological Object.

Also, every Person IsA Actor. A Person may die. However other kinds of Actors, such as companies, don't die (c.f. 2).

Every Biological Object IsA Physical Object. A Physical Object can be moved. Hence a Person can be moved also (c.f. 3).

| superclass | A superclass is a **class** that is a generalization of one or more other classes (its **subclasses**), which means that it subsumes all **instances** of its subclasses, and that it can also have additional instances that do not belong to any of its subclasses. The **intension** of the superclass is less restrictive than any of its subclasses. This subsumption relationship or generalization is the inverse of the IsA relationship or specialization.

In some contexts (e.g. the programming language C++) the term parent class is used synonymously with superclass.

For example:

"Biological Object subsumes Person" is synonymous with "Biological Object is a superclass of Person". It needs fewer traits to identify an item as a Biological Object than to identify it as a Person. |

| intension | The intension of a **class** or **property** is its intended meaning. It consists of one or more common traits shared by all **instances** of the class or property. These traits need not be explicitly formulated in logical terms, but may just be described in a text (here called a **scope note**) that refers to a conceptualisation common to domain experts. In particular the so-called **primitive** concepts, which make up most of the CIDOC CRM, cannot be further reduced to other concepts by logical terms. |

| extension | The extension of a **class** is the set of all real life **instances** belonging to the class that fulfil the criteria of its **intension**. This set is "open" in the sense that it is generally beyond our capabilities to know all instances of a class in the world and indeed that the future may bring new instances about at any time (**Open World**). |

An information system may at any point in time refer to some instances of a class, which form a subset of its extension.

scope note	A scope note is a textual description of the **intension** of a **class** or **property.**

Scope notes are not formal modelling constructs, but are provided to help explain the intended meaning and application of the CIDOC CRM's classes and properties. Basically, they refer to a conceptualisation common to domain experts and disambiguate between different possible interpretations. Illustrative example **instances** of classes and properties are also regularly provided in the scope notes for explanatory purposes.

instance	An instance of a **class** is a real world item that fulfils the criteria of the **intension** of the class. Note, that the number of **instances** declared for a class in an information system is typically less than the total in the real world. For example, you are an instance of Person, but you are not mentioned in all information systems describing Persons.

For example:

The painting known as the "The Mona Lisa" is an instance of the class Man Made Object.

An instance of a **property** is a factual relation between an instance of the **domain** and an instance of the **range** of the property that matches the criteria of the **intension** of the property.

For example:

The Mona Lisa *has former or current owner.* The Louvre is an instance of the property *P51 has former or current owner (is former or current owner of).*

property	A property serves to define a relationship of a specific kind between two **classes.** The property is characterized by an **intension**, which is conveyed by a **scope note.** A property plays a role analogous to a grammatical verb, in that it must be defined with reference to both its **domain** and **range**, which are analogous to the subject and object in grammar (unlike classes, which can be defined independently). It is arbitrary, which class is selected as the domain, just as the choice between active and passive voice in grammar is arbitrary. In other words, a property can be interpreted in both directions, with two distinct, but related

interpretations. Properties may themselves have properties that relate to other classes (This feature is used in this model only in order to describe dynamic subtyping of properties). Properties can also be specialized in the same manner as classes, resulting in IsA relationships between **subproperties** and their **superproperties**.

In some contexts, the terms attribute, reference, link, role or slot are used synonymously with property.

For example:

"Physical Human-Made Thing *depicts* CRM Entity" is equivalent to "CRM Entity *is depicted by* Physical Human-Made Thing".

inverse of   The inverse of a property is the reinterpretation of a **property** from **range** to **domain** without more general or more specific meaning, similar to the choice between active and passive voice in some languages. In contrast to some knowledge representation languages, such as RDF and OWL, we regard that the inverse of a property is not a property in its own right that needs an explicit declaration of being inverse of another, but an interpretation implicitly existing for any property. The inverse of the inverse of a property is identical to the property itself, i.e. its primary sense of direction.

For example:

"CRM Entity *is depicted by* Physical Human-Made Thing" is the inverse of "Physical Human-Made Thing *depicts* CRM Entity"

subproperty   A subproperty is a **property** that is a specialization of another property (its **superproperty**). Specialization or IsA relationship means that:

1. all **instances** of the subproperty are also instances of its superproperty,
2. the **intension** of the subproperty extends the intension of the superproperty, i.e. its traits are more restrictive than that of its superproperty,
3. the **domain** of the subproperty is the same as the domain of its superproperty or a **subclass** of that domain,
4. the **range** of the subproperty is the same as the range of its superproperty or a subclass of that range,
5. the subproperty inherits the definition of all of the properties declared for its superproperty without exceptions (**strict inheritance**), in addition to having none, one or more properties of its own.

A subproperty can have more than one immediate superproperty and consequently inherits the properties of all of its superproperties (**multiple inheritance**). The IsA relationship or specialization between two or more properties gives rise to the structure we call a property hierarchy. The IsA relationship is transitive and may not be cyclic.

Some object-oriented programming languages, such as C++, do not contain constructs that allow for the expression of the specialization of properties as sub-properties.

Alternatively, a property may be subproperty of the **inverse of** another property, i.e. reading the property from range to domain. In that case,

1. all instances of the subproperty are also instances of the inverse of the other property,
2. the intension of the subproperty extends the intension of the inverse of the other property, i.e. its traits are more restrictive than that of the inverse of the other property,
3. the domain of the subproperty is the same as the range of the other property or a subclass of that range,
4. the range of the subproperty is the same as the domain of the other property or a subclass of that domain,
5. the subproperty inherits the definition of all of the properties declared for the other property without exceptions (strict inheritance), in addition to having none, one or more properties of its own. The definitions of inherited properties have to be interpreted in the inverse sense of direction of the subproperty, i.e., from range to domain.

superproperty   A superproperty is a **property** that is a generalization of one or more other properties (its **subproperties**), which means that it subsumes all **instances** of its subproperties, and that it can also have additional instances that do not belong to any of its subproperties. The **intension** of the superproperty is less restrictive than any of its subproperties. The subsumption relationship or generalization is the inverse of the IsA relationship or specialization. A superproperty may be a generalization of the **inverse of** another property

domain   The domain is the **class** for which a **property** is formally defined. This means that **instances** of the property are applicable to instances of its domain class. A property must have exactly one domain, although the domain class may always contain instances for which the property is not instantiated. The domain class is analogous to the grammatical subject of the phrase for which the property is analogous to the verb. It is arbitrary, which class is selected as the domain and which as the **range**, just as the choice between active and passive voice in

grammar is arbitrary. Property names in the CIDOC CRM are designed to be semantically meaningful and grammatically correct when read from domain to range. In addition, the inverse property name, normally given in parentheses, is also designed to be semantically meaningful and grammatically correct when read from range to domain.

range	The range is the **class** that comprises all potential values of a **property.** That means that **instances** of the property can link only to instances of its range class. A property must have exactly one range, although the range class may always contain instances that are not the value of the property. The range class is analogous to the grammatical object of a phrase for which the property is analogous to the verb. It is arbitrary, which class is selected as **domain** and which as range, just as the choice between active and passive voice in grammar is arbitrary. Property names in the CIDOC CRM are designed to be semantically meaningful and grammatically correct when read from domain to range. In addition the inverse property name, normally given in parentheses, is also designed to be semantically meaningful and grammatically correct when read from range to domain.

inheritance	Inheritance of **properties** from **superclasses** to **subclasses** means that if an item x is an **instance** of a **class** A, then

1. all properties that must hold for the instances of any of the superclasses of A must also hold for item x, and

all optional properties that may hold for the instances of any of the superclasses of A may also hold for item x.

strict inheritance	Strict **inheritance** means that there are no exceptions to the inheritance of **properties** from **superclasses** to **subclasses**. For instance, some systems may declare that elephants are grey, and regard a white elephant as an exception. Under strict inheritance it would hold that: if all elephants were grey, then a white elephant could not be an elephant. Obviously not all elephants are grey. To be grey is not part of the **intension** of the concept elephant but an optional property. The CIDOC CRM applies strict inheritance as a normalization principle.

multiple inheritance	Multiple **inheritance** means that a **class** A may have more than one immediate **superclass**. The **extension** of a class with multiple immediate superclasses is a subset of the intersection of all extensions of its superclasses. The **intension** of a class with multiple immediate superclasses extends the intensions of all its superclasses, i.e. its traits are more restrictive than any of its superclasses. If

multiple inheritance is used, the resulting "class hierarchy" is a directed graph and not a tree structure. If it is represented as an indented list, there are necessarily repetitions of the same class at different positions in the list.

For example, Person is both, an Actor and a Biological Object.

Multiple Instantiation	Multiple **Instantiation** is the term that describes the case that an instance of class A is also regarded as an instance of one or more other classes B1...n at the same time. When multiple instantiation is used, it has the effect that the properties of all these classes become available to describe this instance. For instance, some particular cases of destruction may also be activities (e.g.,Herostratos' deed), but not all destructions are activities (e.g., destruction of Herculaneum). In comparison, multiple inheritance describes the case that all instances of a class A are implicitly instances of all superclasses of A, by virtue of the definition of the class A, whereas the combination of classes used for multiple instantiation is a characteristic of particular instances only. It is important to note that multiple instantiation is not allowed using combinations of disjoint classes.
endurant, perdurant	"The difference between enduring and perduring entities (which we shall also call *endurants* and *perdurants*) is related to their behaviour in time. Endurants are wholly present (i.e., all their proper parts are present) at any time they are present. Perdurants, on the other hand, just extend in time by accumulating different temporal parts, so that, at any time they are present, they are only partially present, in the sense that some of their proper temporal parts (e.g., their previous or future phases) may be not present. E.g., the piece of paper you are reading now is wholly present, while some temporal parts of your reading are not present any more. Philosophers say that endurants are entities that are in time, while lacking however temporal parts (so to speak, all their parts flow with them in time). Perdurants, on the other hand, are entities that happen in time, and can have temporal parts (all their parts are fixed in time)." (Gangemi et al. 2002, pp. 166-181).
shortcut	A shortcut is a formally defined single **property** that represents a deduction or join of a data path in the CIDOC CRM. The **scope notes** of all properties characterized as shortcuts describe in words the equivalent deduction. Shortcuts are introduced for the cases where common documentation practice refers only to the deduction rather than to the fully developed path. For example, museums often only record the dimension of an object without documenting the Measurement that observed it. The CIDOC CRM declares shortcuts explicitly as single properties in order to allow the user to describe cases in which he has less detailed knowledge than the full data path would need to be described. For each

shortcut, the CIDOC CRM contains in its schema the properties of the full data path explaining the shortcut.

monotonic reasoning	Monotonic reasoning is a term from knowledge representation. A reasoning form is monotonic if an addition to the set of propositions making up the knowledge base never determines a decrement in the set of conclusions that may be derived from the knowledge base via inference rules. In practical terms, if experts enter subsequently correct statements to an information system, the system should not regard any results from those statements as invalid, when a new one is entered. The CIDOC CRM is designed for monotonic reasoning and so enables conflict-free merging of huge stores of knowledge.
disjoint	**Classes** are disjoint if the intersection of their **extensions** is an empty set. In other words, they have no common **instances** in any possible world.
primitive	The term primitive as used in knowledge representation characterizes a concept that is declared and its meaning is agreed upon, but that is not defined by a logical deduction from other concepts. For example, mother may be described as a female human with child. Then mother is not a primitive concept. Event however is a primitive concept. Most of the CIDOC CRM is made up of primitive concepts.
Open World	The "Open World Assumption" is a term from knowledge base systems. It characterizes knowledge base systems that assume the information stored is incomplete relative to the universe of discourse they intend to describe. This incompleteness may be due to the inability of the maintainer to provide sufficient information or due to more fundamental problems of cognition in the system's domain. Such problems are characteristic of cultural information systems. Our records about the past are necessarily incomplete. In addition, there may be items that cannot be clearly assigned to a given **class**. In particular, absence of a certain **property** for an item described in the system does not mean that this item does not have this property. For example, if one item is described as Biological Object and another as Physical Object, this does not imply that the latter may not be a Biological Object as well. Therefore **complements** of a class with respect to a **superclass** cannot be concluded in general from an information system using the Open World Assumption. For example, one cannot list "all Physical Objects known to the system that are not Biological Objects in the real world", but one may of course list "all items known to the system as Physical Objects but that are not known to the system as Biological Objects".

complement	The complement of a class A with respect to one of its **superclasses** B is the set of all **instances** of B that are not instances of A. Formally, it is the set-theoretic difference of the **extension** of B minus the extension of A. Compatible extensions of the CIDOC CRM should not declare any **class** with the **intension** of them being the complement of one or more other classes. To do so will normally violate the desire to describe an **Open World**. For example, for all possible cases of human gender, male should not be declared as the complement of female or vice versa. What if someone is both or even of another kind?
query containment	Query containment is a problem from database theory: A query X contains another query Y, if for each possible population of a database the answer set to query X contains also the answer set to query Y. If query X and Y were classes, then X would be **superclass** of Y.
interoperability	Interoperability means the capability of different information systems to communicate some of their contents. In particular, it may mean that

1. two systems can exchange information, and/or
2. multiple systems can be accessed with a single method.

Generally, syntactic interoperability is distinguished from **semantic interoperability**. Syntactic interoperability means that the information encoding of the involved systems and the access protocols are compatible, so that information can be processed as described above without error. However, this does not mean that each system processes the data in a manner consistent with the intended meaning. For example, one system may use a table called "Actor" and another one called "Agent". With syntactic interoperability, data from both tables may only be retrieved as distinct, even though they may have exactly the same meaning. To overcome this situation, semantic interoperability has to be added. The CIDOC CRM relies on existing syntactic interoperability and is concerned only with adding *semantic interoperability*.

semantic interoperability	Semantic **interoperability** means the capability of different information systems to communicate information consistent with the intended meaning. In more detail, the intended meaning encompasses

1. the data structure elements involved,
2. the terminology appearing as data and
3. the identifiers used in the data for factual items such as places, people, objects etc.

Obviously communication about data structure must be resolved first. In this case consistent communication means that data can be transferred between data structure elements with the same intended meaning or that data from elements with the same intended meaning can be merged. In practice, the different levels of generalization in different systems do not allow the achievement of this ideal. Therefore semantic interoperability is regarded as achieved if elements can be found that provide a reasonably close generalization for the transfer or merge. This problem is being studied theoretically as the **query containment** problem. The CIDOC CRM is only concerned with semantic interoperability on the level of data structure elements.

property quantifiers	We use the term "property quantifiers" for the declaration of the allowed number of **instances** of a certain **property** that can refer to a particular instance of the **range** class or the **domain** class of that property. These declarations are ontological, i.e. they refer to the nature of the real world described and not to our current knowledge. For example, each person has exactly one father, but collected knowledge may refer to none, one or many.
universal	The fundamental ontological distinction between universals and particulars can be informally understood by considering their relationship with instantiation: particulars are entities that have no **instances** in any possible world; universals are entities that do have instances. **Classes** and **properties** (corresponding to predicates in a logical language) are usually considered to be universals. (after Gangemi et al. 2002, pp. 166-181).
Knowledge Creation Process	All knowledge contained in an information system must have been introduced into that system by some human agent, either directly or indirectly. Despite this fact, many, if not most, statements within such a system will lack specific attribution of authority. That being said, in the domain of cultural heritage, it is common practice that, for the processes of collection documentation and management, there are clearly and explicitly elaborated systems of responsibility outlining by whom and how knowledge can be added and or modified in the system. Ideally these systems are specified in institutional policy and protocol documents. Thus, it is reasonable to hold that all such statements that lack explicit authority attribution within the information system can, in fact, be read as the official view of the administrating institution of that system.
	Such a position does not mean to imply that an information system represents at any particular moment a completed phase of knowledge that the institution promotes. Rather, it means to underline that, in a CH context, a managed set of data, at any state of elaboration, will in fact embody an adherence to some explicit code of standards which guarantees the validity of that data within the scope of said standards and all practical limitations. So long as the information is

under active management it remains continuously open to revision and improvement as further research reveals further understanding surrounding the objects of concern.

A distinct exception to this rule is represented by information in the data set that carries with it an explicit statement of responsibility.

In CIDOC CRM such statements of responsibility are expressed though knowledge creation events such as E13 Attribute Assignment and its relevant subclasses. Any information in a CIDOC CRM model that is based on an explicit creation event for that piece of information, where the creator's identity has been given, is attributed to the authority and assigned to the responsibility of the actor identified as causal in that event. For any information in the system connected to knowledge creation events that do not explicitly reference their creator, as well as any information not connected to creation events, the responsibility falls back to the institution responsible for the database/knowledge graph. That means that for information only expressed through shortcuts such as 'P2 has type', where no knowledge creation event has been explicitly specified, the originating creation event cannot be deduced and the responsibility for the information can never be any other body than the institution responsible for the whole information system.

In the case of an institution taking over stewardship of a database transferred into their custody, two relations of responsibility for the knowledge therein can be envisioned. If the institution accepts the dataset and undertakes to maintain and update it, then they take on responsibility for that information and become the default authority behind its statements as described above. If, on the other hand, the institution accepts the data set and stores it without change as a closed resource, then it can be considered that the default authority remains the original steward.

| Transitivity | Transitivity is defined in the standard way found in mathematics or logic: A property P is transitive if the domain and range is the same class and for all instances x, y, z of this class the following is the case: If x is related by P to y and y is related by P to z, then x is related by P to z. The intention of a property as described in the scope note will decide whether a property is transitive or not. For example, the property P121 overlaps with between instances of E53 Place is not transitive, while the property P89 falls within (contains) between instances of E53 Place and the property P46 is composed of (forms part of) between instances of E18 Physical Thing are both transitive. Transitivity is especially useful when CIDOC CRM is implemented in a system with deduction |

Compatibility with the CIDOC CRM

Users intending to take advantage of the semantic interoperability offered by the CIDOC CRM should ensure conformance with the relevant data structures. Conformance pertains either to data to be made accessible in an integrated environment or intended for transport to other environments. Any encoding

of data in a formal language that preserves the relations of the classes, properties, and inheritance rules defined by this International Standard, is regarded as conformant.

Conformance with the CIDOC CRM does not require complete matching of all local documentation structures, nor that all concepts and structures present in this International Standard be implemented. this International Standard is intended to allow room both for extensions, needed to capture the full richness of cultural documentation, and for simplification, in the interests of economy. A system will be deemed partially conformant if it supports a subset of subclasses and sub properties defined by this International Standard. Designers of the system should publish details of the constructs that are supported.

The focus of the CIDOC CRM is the exchange and mediation of structured information. It does not require the interpretation of unstructured (free text) information into a structured, logical form. Unstructured information is supported, but falls outside the scope of conformance considerations.

Any documentation system will be deemed conformant with this International Standard, regardless of the internal data structures it uses; if a deterministic logical algorithm can be constructed, that transforms data contained in the system into a directly compatible form without loss of meaning.

No assumptions are made as to the nature of this algorithm. "Without loss of meaning" signifies that designers and users of the system are satisfied that the data representation corresponds to the semantic definitions provided by this International Standard.

Property Quantifiers

Quantifiers for properties are provided for the purpose of semantic clarification only, and should **not** be treated as implementation recommendations. The CIDOC CRM has been designed to accommodate alternative opinions and incomplete information, and therefore **all** properties should be implemented as optional and repeatable for their domain and range ("many to many (0,n:0,n)"). Therefore the term "cardinality constraints" is avoided here, as it typically pertains to implementations.

The following table lists all possible property quantifiers occurring in this document by their notation, together with an explanation in plain words. In order to provide optimal clarity, two widely accepted notations are used redundantly in this document, a verbal and a numeric one. The verbal notation uses phrases such as "one to many", and the numeric one, expressions such as "(0,n:0,1)". While the terms "one", "many" and "necessary" are quite intuitive, the term "dependent" denotes a situation where a range instance cannot exist without an instance of the respective property. In other words, the property is "necessary" for its range. (Meghini, C. & Doerr, M., 2018)

many to many (0,n:0,n)	Unconstrained: An individual domain instance and range instance of this property can have zero, one or more instances of this property. In other words, this property is optional and repeatable for its domain and range.

one to many **(0,n:0,1)**	An individual domain instance of this property can have zero, one or more instances of this property, but an individual range instance cannot be referenced by more than one instance of this property. In other words, this property is optional for its domain and range, but repeatable for its domain only. In some contexts this situation is called a "fan-out".
many to one **(0,1:0,n)**	An individual domain instance of this property can have zero or one instance of this property, but an individual range instance can be referenced by zero, one or more instances of this property. In other words, this property is optional for its domain and range, but repeatable for its range only. In some contexts this situation is called a "fan-in".
many to many, necessary **(1,n:0,n)**	An individual domain instance of this property can have one or more instances of this property, but an individual range instance can have zero, one or more instances of this property. In other words, this property is necessary and repeatable for its domain, and optional and repeatable for its range.
one to many, necessary **(1,n:0,1)**	An individual domain instance of this property can have one or more instances of this property, but an individual range instance cannot be referenced by more than one instance of this property. In other words, this property is necessary and repeatable for its domain, and optional but not repeatable for its range. In some contexts this situation is called a "fan-out".
many to one, necessary **(1,1:0,n)**	An individual domain instance of this property must have exactly one instance of this property, but an individual range instance can be referenced by zero, one or more instances of this property. In other words, this property is necessary and not repeatable for its domain, and optional and repeatable for its range. In some contexts this situation is called a "fan-in".
one to many, dependent **(0,n:1,1)**	An individual domain instance of this property can have zero, one or more instances of this property, but an individual range instance must be referenced by exactly one instance of this property. In other words, this property is optional and repeatable for its domain, but necessary and not repeatable for its range. In some contexts this situation is called a "fan-out".

one to many, necessary, dependent **(1,n:1,1)**	An individual domain instance of this property can have one or more instances of this property, but an individual range instance must be referenced by exactly one instance of this property. In other words, this property is necessary and repeatable for its domain, and necessary but not repeatable for its range. In some contexts this situation is called a "fan-out".
many to one, necessary, dependent **(1,1:1,n)**	An individual domain instance of this property must have exactly one instance of this property, but an individual range instance can be referenced by one or more instances of this property. In other words, this property is necessary and not repeatable for its domain, and necessary and repeatable for its range. In some contexts this situation is called a "fan-in".
one to one **(1,1:1,1)**	An individual domain instance and range instance of this property must have exactly one instance of this property. In other words, this property is necessary and not repeatable for its domain and for its range.

The CIDOC CRM defines some dependencies between properties and the classes that are their domains or ranges. These can be one or both of the following:

A) the property is necessary for the domain

B) the property is necessary for the range, or, in other words, the range is dependent on the property.

The possible kinds of dependencies are defined in the table above. Note that if a dependent property is not specified for an instance of the respective domain or range, it means that the property exists, but the value on one side of the property is unknown. In the case of optional properties, the methodology proposed by the CIDOC CRM does not distinguish between a value being unknown or the property not being applicable at all. For example, one may know that an object has an owner, but the owner is unknown. In a CIDOC CRM instance this case cannot be distinguished from the fact that the object has no owner at all. Of course, such details can always be specified by a textual note.

Naming Conventions

The following naming conventions have been applied throughout the CIDOC CRM:

- Classes are identified by numbers preceded by the letter "E" (historically classes were sometimes referred to as "Entities"), and are named using noun phrases (nominal groups) using title case (initial capitals). For example, E63 Beginning of Existence.
- Properties are identified by numbers preceded by the letter "P," and are named in both directions using verbal phrases in lower case. Properties with the character of states are named in the present tense, such as "has type", whereas properties related to events are named in past tense, such as "carried out." For example, *P126 employed (was employed in)*.
- Property names should be read in their non-parenthetical form for the domain-to-range direction, and in parenthetical form for the range-to-domain direction. Reading a property in range-to-domain

direction is equivalent to the inverse of that property. Following a current notational practice in OWL knowledge representation language, we represent inverse properties in this text by adding a letter "i" following the identification number and the parenthetical form of the full property name, such as *P59i is located on or within*, which is the inverse of *P59 has section (is located on or within).*

- Properties with a range that is a subclass of E59 Primitive Value (such as *E1 CRM Entity. P3 has note: E62 String*, for example) have no parenthetical name form, because reading the property name in the range-to-domain direction is not regarded as meaningful.
- Properties that have identical domain and range are either symmetric or transitive. Instantiating a symmetric property implies that the same relation holds for both the domain-to-range and the range-to-domain directions. An example of this is *E53 Place. P122 borders with: E53 Place*. The names of symmetric properties have no parenthetical form, because reading in the range-to-domain direction is the same as the domain-to-range reading. Transitive asymmetric properties, such as *E4 Period. P9 consist of (forms part of): E4 Period*, have a parenthetical form that relates to the meaning of the inverse direction.
- The choice of the domain of properties, and hence the order of their names, are established in accordance with the following priority list:
  - Temporal Entity and its subclasses
  - Thing and its subclasses
  - Actor and its subclasses
  - Other

About the logical expressions used in the CIDOC CRM

Comment (2) to the work done by the editorial group.

The text of this section has been reformulated and the overview over logical operators is new. The edtitorial group considers this to be uncontroversial editing. Formally this work is a part of the ISSUE 459: Modelling Principles (Intro to the CRM)

End comment (2)

The present CIDOC CRM specifications are annotated with logical axioms, providing an additional formal expression of the CIDOC CRM ontology. This section briefly introduces the assumptions that are at the basis of the logical expression of the CIDOC CRM (for a fully detailed account of the logical expression of semantic data modelling, see [1][5]).

The CIDOC CRM is expressed in terms of the primitives of semantic data modelling. As such, it consists of:

- *classes,* which represent general notions in the domain of discourse, such as the CIDOC CRM class *E21 Person* which represents the notion of person;
- *properties,* which represent the binary relations that link the individuals in the domain of discourse, such as the CIDOC CRM property *P152 has parent* linking a person to one of the person's parent.

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[5] [1] R. Reiter (1984). Towards a logical reconstruction of relational database theory. In Brodie, M. L., Mylopoulos, J., and Schmidt, J. W., editors, On Conceptual Modelling, pages 191–233. Springer Verlag, New York, NY

Classes and properties are used to express ontological knowledge by means of various kinds of constraints, such as sub-class/sub-property links, e.g., *E21 Person* is a sub-class of *E20 Biological Object*, or domain/range constraints, e.g., the domain of *P152 has parent* is class *E21 Person.*

In contrast, first-order logic-based knowledge representation relies on a language for formally encoding an ontology. This language can be directly put in correspondence with semantic data modelling in a straightforward way:

- classes are named by *unary predicate symbols*; conventionally, we use E21 as the unary predicate symbol corresponding to class *E21 Person*;
- properties are named by *binary predicate symbols*; conventionally, we use P152 as the binary predicate symbol corresponding to property *P152 has parent.*
- properties of properties, ".1 properties" are named by *ternary predicate symbols*; conventionally, we use P14.1 as the ternary predicate symbol corresponding to property *P14.1 preformed in the role of has parent.*

Ontology is expressed in logic by means of *logical axioms*, which correspond to the constraints of semantic modelling. In the definition of classes and properties of the CIDOC CRM the axioms are placed under the heading 'In first order logic'. There are several options for writing statements in first order logic. In this document we use a standard compact notation widely used in text books and scientific papers. The definition is given in the table below.

Symbol	Name	reads	Truth value
Operators			
$\wedge$	conjunction	and	$(\varphi \wedge \psi)$ is true if and only if both φ and ψ are true
$\vee$	disjunction	or	$(\varphi \vee \psi)$ is true if and only if at least one of either φ or ψ is true
$\neg$	negation	not	$\neg\varphi$ is true if and only if φ is false
$\rightarrow$	implication	implies, if … then ..	$(\varphi \rightarrow \psi)$ is true if and only if it is not the case that φ is true and ψ is false
$\leftrightarrow$	equivalence	is equivalent to, if … and only if …	$\varphi \leftrightarrow \psi$ is true if and only if both φ and ψ are true or both φ and ψ are false

Quantifiers			
∃	existential quantifier	exists, there exists at least one	
∀	Universal quantifier	forall, for all	

For instance, the above sub-class link between *E21 Person* and *E20 Biological Object* can be formulated in first order logic as the axiom:

$$(\forall x)\ [E21(x) \rightarrow E20(x)]$$

(reading: for all individuals x, if x is a E21 then x is an E20).

In the definitions of classes and properties in this document the universal quantifier(s) are omitted for simplicity, so the above axiom is simply written:

$$E21(x) \rightarrow E20(x)$$

Likewise, the above domain constraint on property *P152 has parent* can be formulated in first order logic as the axiom:

$$P152(x,y) \rightarrow E21(x)$$

(reading: for all individuals x and y, if x is a P152 of y, then x is an E21).

These basic considerations should be used by the reader to understand the logical axioms that are used into the definition of the classes and properties. Further information about the first order formulation of CIDOC CRM can be found in (Meghini & Doerr, 2018)

Modelling principles

The following modelling principles have guided and informed the development of the CIDOC CRM.

Reality, Knowledge Bases and CIDOC CRM

Comment (3) to the work done by the editorial group.
The text of the first paragraph marked in yellow is reformulated and two new footnotes are introduced. The original text is in the comment. The editorial group considers this to be uncontroversial editing. Formally this work is a part of the ISSUE 459: Modelling Principles (Intro to the CRM)

End comment (3)

The CIDOC CRM is a formal ontology in the sense introduced by N. Guarino (1998)[6]. The present document is intended to embrace an audience not specialized in computer science and logic; therefore, it focuses on the informal semantics and on the pragmatics of the CIDOC CRM concepts, offering a detailed discussion of the main traits of the conceptualization underlying the CIDOC CRM through basic usage patterns[7]. The CIDOC CRM aims to assist sharing, connecting and integrating information from research about the past. In order to understand the function of a formal ontology of this kind, one needs to make the following distinctions:

- The *material reality*. For the purpose of the CIDOC CRM, material reality is regarded as whatever has substance that can be perceived with senses or instruments. Examples are people, a forest or a settlement environment, sea, atmosphere, distant celestial or cellular micro structures, including what we assume could be potentially or theoretically perceived if we could be there, such as the center of Earth or the sun, and all that is past. It is constrained to space and time. What goes on in *our minds* or is produced by our minds is also regarded as part of the material reality, as it becomes materially evident to other people at least by our utterances, behavior and products.

- The units of description or *particulars*, i.e., the things and relations which we refer to in order to distinguish parts of reality. Examples are Mount Ida, the Taj Mahal, the formation of China by emperor Qin Shi Huang (秦始皇) in 221BC, Tut-Ankh Amun and his embalming, Prince Shotoku of Japan sending a mission to China in 607AD, the participation of Socrates in the Battle of Potidaea or the radiocarbon dating of the Iceman Ötzi[8].

A formal ontology, such as the CIDOC CRM, constitutes a controlled language for talking about particulars. I.e., it provides classes and properties for categorizing particulars as so-called "instances" in

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[6] Nicola Guarino defines a formal ontology as a specification of a set of named concepts used to describe and approximate a part of reality, plus a first-order logical theory narrowing down the intended meaning of the named concepts.

[7] For the readers interested in computer science and logic, the syntax and formal semantics employed by the CIDOC CRM are given by Meghini & Doerr (2018), where the computational aspects are also discussed.

[8] Kutschera, Walter. "Radiocarbon dating of the Iceman Ötzi with accelerator mass spectrometry." (2002).

a way that their individuation, unity and relevant properties are as unambiguous as possible. For instance, Tut-Ankh Amun as instance of E21 Person *is* the real pharaoh from his birth to death, and not extending to his mummy, as follows from the specification of the class E21 Person and its properties in the CIDOC CRM.

For clarification, the CIDOC CRM does not take a position against or in favour of the existence of spiritual substance nor of substance not accessible by either senses or instruments, nor does it suggest a materialistic philosophy. However, for practical reasons, it relies on the priority of integrating information based on material evidence available for whatever human experience. The CIDOC CRM only commits to a unique material reality independent from the observer.

When we *provide descriptions* of particulars, we need to refer to them by unique names, titles or constructed identifiers, all of which are instances of E41 Appellation in the CIDOC CRM, in order the reference to be independent of the context. (In contrast, reference to particulars by pronouns or enumerations of characteristic properties, such as name and birth date, are context dependent). The appellation, and the relation between the appellation and the referred item or relationship, must not be confused with the referred item and its identity. For example, Tut-Ankh Amun the name (instance of E41 Appellation) is different from Tut-Ankh Amun the person (instance of E21 Person) and also different from the relationship between name and person (*P1 is identified by*). Instances of CIDOC CRM classes are the *real* particulars, not their names, but in descriptions, names must be used as surrogates for the real things meant. Particulars are approximate individuations, like sections, of parts of reality. In other words, the uniqueness of reality does not depend on where one draws the line between the mountain and the valley.

A CIDOC CRM-compatible *knowledge base* (KB)[9] is an instance of E73 Information Object in the CIDOC CRM. It contains (data structures that encode) formal statements representing propositions believed to be true in a reality by an observer. These statements use appellations (e.g. http://id.loc.gov/authorities/names/n79066005[10]) of ontological particulars and of CRM concepts (e.g. *P100i died in*). Thereby users, in their capacity of having real-world knowledge and cognition, may be able to relate these statements to the propositions they are meant to characterize, and be able to reason and research about their validity. In other words, the formal instances in a knowledge base are the *identifiers*, not the real things or phenomena. A special case is digital content: a KB in a computer system may contain statements about instances of E90 Symbolic Object and the real thing may be text residing within the same KB. The instance of E90 Symbolic Object and its textual representation are separate entities and they can be connected with the property *P190 has symbolic content.*

Therefore, a knowledge base does not contain knowledge, but *statements that represent* knowledge, as long as there exist people that can resolve the identifiers used to their referents. (Appellations described in a knowledge base, and not used as primary substitutes of other items, are of course explicitly declared as instances of E41 Appellation in the knowledge base.)

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[9] (Meghini & Doerr 2018)

[10] The URI (instance of E41 Appellation) of the Library of Congress for Tut-Ankh-Amun, the pharaoh.

Authorship of Knowledge Base Contents

This section describes a recommended good practice how to relate authority to knowledge base contents.

Statements in a KB must have been inserted by some human agent, either directly or indirectly. However, these statements often make no reference to that agent, lacking attribution of authority. An example of such statements in the CIDOC CRM is information expressed through shortcuts such as 'P2 has type'. In the domain of cultural heritage, it is common practice that the responsibility for maintaining knowledge in the KB is elaborated in institutional policy or protocol documents. Thus, it is reasonable to hold that statements which lack explicit authority attribution can be read as the official view of the administrating institution of that system, i.e. the maintainers of the KB. This does not imply that the knowledge described in the KB is complete. So long as the information is under active management it remains continuously open to revision and improvement as further research reveals further understandings. Statements in a KB may be in contradiction to the ontologically defined quantification of properties without the KB being broken or invalid in any sense, either because necessary properties are unknown or there exist good reasons to assume alternative values for properties with limited cardinality, be it by the same or by different maintainers. A KB does not represent a slice of reality, but the justified beliefs of its maintainers about that reality. For simplicity we speak about a KB as representing some reality.

Statements in a KB may also carry explicit references to agents that produced them, i.e. further statements of responsibility. In CIDOC CRM such statements of responsibility are expressed though knowledge creation events such as E13 Attribute Assignment and its relevant subclasses. Any knowledge that is based on an explicit creation event, where the creator's identity has been given, is attributed to the authority and assigned to the responsibility of the agent identified as causal in that event.

In the special case of an institution taking over stewardship of a database transferred into their custody, two relations of responsibility for the knowledge therein can be envisioned. If the institution accepts the dataset and undertakes to maintain and update it, then they take on responsibility for that information and become the default authority behind its statements as described above. If, on the other hand, the institution accepts the data set and stores it without change as a closed resource, then it can be considered that the default authority remains the original steward like for any other scholarly document kept by the institution.

Extensions of CIDOC CRM

Since the intended scope of the CIDOC CRM is a subset of the "real" world and is therefore potentially infinite, the model has been designed to be extensible through the linkage of compatible external type hierarchies.

Of necessity, some concepts covered by the CIDOC CRM are defined in less details than others: E39 Actor and E30 Right, for example. This is a natural consequence of staying within the model's clearly articulated practical scope in an intrinsically unlimited domain of discourse. These 'underdeveloped' concepts can be considered as candidate superclasses for compatible extensions, in particular for

disciplines with a respective focus. Additions to the model are known as extensions while the main model is known as CRMbase.

Compatibility of extensions with the CRM means that data structured according to an extension must also remain valid as instances of CIDOC CRM base classes. In practical terms, this implies query containment: any queries based on CIDOC CRM concepts to a KB should retrieve a result set that is correct according to the model's semantics, regardless of whether the KR is structured according to the CIDOC CRM's semantics alone, or according to the CIDOC CRM plus compatible extensions. For example, a query such as "list all events" should recall 100% of the instances deemed to be events by the CIDOC CRM, regardless of how they are classified by the extension.

A sufficient condition for the compatibility of an extension with the CIDOC CRM is that its classes, other than E1 CRM Entity, subsume all classes of the extension, and all properties of the extension are either subsumed by CRM properties, or are part of a path for which a CIDOC CRM property is a shortcut, and that classes and properties of the extension can be well distinguished from those in the CIDOC CRM. For instance, a class "tangible object" may be in conflict with existing classes of the CIDOC CRM. Obviously, such a condition can only be tested intellectually.

The CRM provides a number of mechanisms to ensure that coverage of the intended scope can be increased on demand without loosing compatibility:

1.   Existing classes can be extended, either structurally as subclasses or dynamically using the type hierarchy (see section About Types below).

2.   Existing properties can be extended, either structurally as subproperties, or in some cases, dynamically, using properties of properties which allow subtyping (see section About Types below).

3.   Additional information that falls outside the semantics formally defined by the CIDOC CRM can be recorded as unstructured data using E1 CRM Entity. P3 has note: E62 String.

4.   Extending the CIDOC CRM by superclasses and properties that pertain to a wider scope. They are called conservative extensions, if they preserve backwards compatibility with instances described with the CIDOC CRM.

Following strategies 1, 2 and 3 will have the result that the CIDOC CRM concepts subsume and thereby cover the extensions. This means that querying an extended knowledge base only with concepts of the CIDOC CRM will nevertheless retrieve all facts described via the extensions.

Comment (4) to the work done by the editorial group.
The text of the second paragraph marked in yellow is reformulated. The original text is in the comment. The editorial group considers this to be uncontroversial editing. Formally this work is a part of the ISSUE 459: Modelling Principles (Intro to the CRM)

End comment (4)

In mechanism 3, the information in the notes is accessible in the respective knowledge base by retrieving the instances of E1 CRM Entity that are domain of *P3 has note*. Keyword search will also work for the content of the note. Rules should be applied to attach a note to the item most specific for the

content. For instance, details about the role of an actor in an activity should be associated with the instance of E7 Activity, and not with the instance of E39 Actor. This approach is preferable when queries relating elements from the content of such notes across the knowledge base are not expected.

In general, only concepts to be used for selecting multiple instances from the knowledge base by formal querying need to be explicitly modelled. This criterion depends on the expected scope and use of the particular knowledge base. The CIDOC CRM prioritizes modelling the kinds of facts one would like to retrieve and relate from heterogeneous content sources, potentially from different institutions. It does not, by way of contrast, focus on the modelling of facts with a more local scope such as the administrative practices internal to an institution.

Mechanism 4, conservative extension, is more complex:

With increasing use of the CIDOC CRM, there is also a need for extensions that model phenomena from a scope wider than the original one of the CIDOC CRM, but which are also applicable to the concepts that do fall within the CIDOC CRM's scope. When this occurs, properties of the CIDOC CRM may be found to be applicable more generally to superclasses of the extension than to those of their current domain or range in the CIDOC CRM. This is a consequence of the key principle of the CIDOC CRM to model "bottom up", i.e., selecting the domains and ranges for properties to be as narrow as they would apply in a well understood fashion in the current scope, thus avoiding making poorly understood generalizations at risk of requiring non-monotonic correction.

The fourth mechanism for extending the CIDOC CRM by conservation extension can be seen to be split into two cases:

1) A new class or property is added to an extension of the CIDOC CRM, which is not covered by superclasses other than E1 CRM Entity or a superproperty in the CIDOC CRM respectively. In this case, all facts described only by such concepts are *not* accessible by queries with CIDOC CRM concepts. Therefore, the extension should *publish* in a compatibility statement the additional relevant high-level classes and properties needed to retrieve all facts documented with the extended model. This case is a monotonic extension.

2) The domain or range of an existing property in the CIDOC CRM is changed to a superclass of the one or the other or both, because the property is understood to be applicable beyond its originally anticipated scope. In this case, all facts described by the extension are still accessible by querying with the concepts of the CIDOC CRM, but the extension can describe additional facts that the CIDOC CRM could not. This case is a monotonic extension and generally recommended, because it enables bottom-up evolution of the model. If this change is part of a new release of the CIDOC CRM itself, it is simply backwards compatible, and this has been done frequently in the evolution of this model.

If case (2) should be documented and implemented in an extension module **separate from** the CIDOC CRM, it may come in conflict with the current way knowledge representation languages, such as RDF/OWL, treat it, because in formal logic changing the range or domain of a property is regarded **as** changing the ontological meaning **completely;** there is no distinction betwe**en the meaning of the**

property independent of domain and range and the specification of the domain and range. It is, however, similar to what in logic is called a conservative extension of a theory, and necessary for an effective modular management of ontologies.

Therefore, for the interested reader, we describe here a definition of this case in terms of first order logic, which shows how modularity can formally be achieved:

Let us assume a property P defined with domain class A and range class C also holds for a domain class B, superclass of A, and a range class D, superclass of C, in the sense of its ontological meaning in the real world. We describe this situation by introducing an auxiliary formal property P', defined with domain class B and range class D, and apply the following logic:

$$A(x) \supset B(x)$$

$$C(x) \supset D(x)$$

$$P(x,y) \supset A(x)$$

$$P(x,y) \supset C(y)$$

$$P'(x,y) \supset B(x)$$

$$P'(x,y) \supset D(y)$$

Then, P' is a conservative extension of P if: $A(x) \land C(y) \land P'(x,y) \equiv P(x,y)$

In other words, a separate extension module may re-declare the respective property with another identifier, preferably using the same label, and implement the above rule.

Minimality

Although the scope of the CIDOC CRM is very broad, the model itself is constructed as economically as possible.

1. CIDOC CRM classes and properties are either primitive, or they are key concepts in the practical scope.
2. Complements of CIDOC CRM classes are not declared, because, considering the Open World principle, there are no properties for complements of a class (see Terminology and first consequence of Monotonicity).

A CIDOC CRM class is declared when:

- It is required as the domain or range of a property not appropriate to its superclass.
- It serves as a merging point of two CIDOC CRM class branches via multiple IsA (e.g. E25 Human-Made Feature). When the branch superclasses are used for multiple instantiation of an item, this item is in the intersection of the scopes. The class resulting from multiple IsA should be narrower in scope than the intersection of the scopes of the branch superclasses.
- It is useful as a leaf class (i.e. at the end of a CIDOC CRM branch) to domain communities building CIDOC CRM extensions or matching key domain classes from other models to the CIDOC CRM (e.g. E34 Inscription).

Shortcuts

Some properties are declared as shortcuts of longer, more comprehensively articulated paths that connect the same domain and range classes as the shortcut property via one or more intermediate

classes. For example, the property *E18 Physical Thing. P52 has current owner (is current owner of): E39 Actor*, is a shortcut for a fully articulated path from E18 Physical Thing through E8 Acquisition to E39 Actor. An instance of the fully-articulated path always implies an instance of the shortcut property. However, the inverse may not be true; an instance of the fully-articulated path cannot always be inferred from an instance of the shortcut property inside the frame of the actual KB

The class E13 Attribute Assignment allows for the documentation of how the assignment of any property came about, and whose opinion it was, even in cases of properties not explicitly characterized as "shortcuts".

Monotonicity

The CIDOC CRM's primary function is to support the meaningful integration of information in an Open World. The adoption of the Open World principle means that the CIDOC CRM itself must remain fundamentally open and knowledge bases implemented using it should be flexible enough to receive new insights. At the model level, new classes and properties within the CIDOC CRM's scope may be found in the course of integrating more documentation records or when new kinds of relevant facts come to the attention of its maintainers. At the level of the KBs, the need to add or revise information may arise due to numerous external factors. Research may open new questions; documentation may be directed to new or different phenomena; natural or social evolution may reveal new objects of study.

It is the aim of the maintainers of the CIDOC CRM to respect the Open World principle and to follow the principle of monotonicity. Monotonicity requires that adding new classes and properties to the model or adding new statements to a knowledge base does not invalidate already modelled structures and existing statements.

A first consequence of this commitment, at the level of the model, is that the CIDOC CRM aims to be monotonic in the sense of Domain Theory. That is to say, the existing CIDOC CRM constructs and the deductions made from them should remain valid and well-formed, even as new constructs are added by extensions to the CIDOC CRM. Any extensions should be, under this method, backwards compatible with previous models. The only exception to this rule arises when a previous construct is considered objectively incorrect by the domain experts and thus subjected to corrective revision. Adopting the principle of monotonicity has active consequences for the basic manner in which classes and properties are designed and declared in the CIDOC CRM. In particular, it forbids the declaration of complement classes, i.e. classes solely defined by excluding instances of some other classes.

For example:

FRBRoo extends the CIDOC CRM. In version 2.4 of FRBRoo, F51 Name Use Activity was declared as a subclass to the CIDOC CRM class E7 Activity. This class was added in order to describe a phenomenon specific to library practice and not considered within CRM base. F51 Name Use Activity describes the practice of an instance of E74 Group adopting and deploying a name within a context for a time-span. The creation of this extension is monotonic because no existing IsA relationship or inheritance of properties in CRM base are compromised and no future extension is ruled out. By way of contrast, if, to handle this situation, a subclass "Other Activity" had been declared, a non-monotonic change would have been introduced. This would be the case because the scope note of a complement class like "Other Activities" would forbid any future declaration of specializations of E7 Activity such as 'Name Use Activity'. In the case the need arose to declare a particular specialized subclass, a non-monotonic

revision would have to be made, since there would be no principled way to decide which instances of 'Other Activity' were instances of the new, specialized class and which were not. Such non-monotonic changes are extremely costly to end users, compromising backwards compatibility and long term integration.

As a second consequence, maintaining monotonicity is also required during revising or augmenting data within a CIDOC CRM compatible system. That is, existing CIDOC CRM instances, their properties and the deductions made from them, should always remain valid and well-formed, even as new instances, regarded as consistent by the domain expert, are added to the system.

For example:

If someone describes correctly that an item is an instance of E19 Physical Object, and later it is correctly characterized as an instance of E20 Biological Object, the system should not stop treating it as an instance of E19 Physical Object. This is achieved by declaring E20 Biological Object as subclass of E19 Physical Object.

This example further demonstrates that the IsA hierarchy of classes and properties can represent characteristic stages of increasing knowledge about some item during the processes of investigation and collection of evidence. Higher level classes can be used to safely classify objects whose precise characteristics are not known in the first instance. An ambiguous biological object may, for example, be classified as only a physical object. Subsequent investigation can reveal its nature as a biological object. A knowledge base constructed with CIDOC CRM classes designed to support monotonic revision allows for seeking physical objects that were not yet recognized as biological ones. This ability to integrate information with different specificity of description in a well-defined way is particularly important for large-scale information integration. Such a system supports scholars being able to integrate all information about potentially relevant phenomena into the information system without forcing an over or under commitment to knowledge about the object. Since large scale information integration always deals with different levels of knowledge of its relevant objects, this feature enables a consistent approach to data integration.

A third consequence, applied at the level of the knowledge base, is that in order to formally preserve monotonicity, when it is required to record and store alternative opinions regarding phenomena all formally defined properties should be implemented as unconstrained (many: many) so that conflicting instances of properties are merely accumulated. Thus integrated knowledge can serve as a research tool for accumulating relevant alternative opinions around well-defined entities, whereas conclusions about the truth are the task of open-ended scientific or scholarly hypothesis building.

For example:

King Arthur's basic life events are highly contested. Once entered in a knowledge base, he should be defined as an instance of E21 Person and treated as having existed as such within the sense of our historical discourse. The instance of E21 Person is used as the collection point for describing possible properties and existence of this individual. Alternative opinions about properties, such as the birthplace and his living places, should be accumulated without validity decisions being made during data compilation. King Arthur may be entered as a different instance, of E28 Conceptual Object, for describing him as mythological character and accumulating possibly mythological facts.

The fourth consequence of monotonicity relates to the use of time dependent properties in a knowledge base. Certain properties declared in the CIDOC CRM, such as having a part, an owner or a location, may change many times for a single item during the course of its existence. Asserting that such a property holds for some item means that that property held for some particular, undetermined time-span within the course of its existence. Consequently, one item may be the subject of multiple statements asserting the instantiation of that property without conflict or need for revision. The collection of such statements would reflect an aggregation of these instances of this property holding over the time-span of the item's existence. If a more specific temporal knowledge is required/available, it is recommended to explicitly describe the events leading to the assertion of that property for that item. For example, in the case of acquiring or losing an item, it would be appropriate to declare the related event class such as E9 Move. By virtue of this principle, the CRM achieves monotonicity with respect to an increase of knowledge about the states of an item at different times, regardless of their temporal order.

Time-neutral properties may be specialized in a future monotonic extension by time-specific properties, but not vice-versa. Also, many properties registered do not change over time or are relative to events in the model already. Therefore, the CIDOC CRM always gives priority to modelling properties as time-neutral, and rather representing changes by events.

However, for some of these properties many databases may describe a "current" state relative to some property, such as "current location" or "current owner". Using such a "current" state means that the database manager is able to verify the respective reality at the latest date of validity of the database. Obviously, this information is non-monotonic, i.e., it requires deletion when the state changes. In order to preserve a reduced monotonicity, these properties have time-neutral superproperties by which respective instances can be reclassified if the validity becomes unknown or no longer holds. Therefore the use of such properties in the CRM is only recommended if they can be maintained consistently. Otherwise, they should be reclassified by their time-neutral superproperties. This holds in particular if data is exported to another repository, see also the paragraph "Authorship of Knowledge Base Contents"

Disjointness

Classes are disjoint if they cannot share any common instances at any time, past, present or future. That implies that it is not possible to instantiate an item using a combination of classes that are mutually disjoint or with subclasses of them (see "multiple instantiation" in section "Terminology"). There are many examples of disjoint classes in the CIDOC CRM.

A comprehensive declaration of all possible disjoint class combinations afforded by the CIDOC CRM has not been provided here; it would be of questionable practical utility, and may easily become inconsistent with the goal of providing a concise definition. However, there are two key examples of disjoint class pairs that are fundamental to effective comprehension of the CIDOC CRM:

a.   **E2 Temporal Entity is disjoint from E77 Persistent Item.** Instances of the class E2 Temporal Entity are perdurants, whereas instances of the class E77 Persistent Item are endurants. Even though instances of E77 Persistent Item have a limited existence in time, they are fundamentally different in nature from instances of E2 Temporal Entity, because they preserve their identity between events. Declaring endurants and perdurants as disjoint classes is consistent with the distinctions made in data structures that fall within the CIDOC CRM's practical scope.

b.   **E18 Physical Thing is disjoint from E28 Conceptual Object.** The distinction is between material and immaterial items, the latter being exclusively human-made. Instances of E18 Physical Thing and E28 Conceptual Object differ in many fundamental ways; for example, the production of instances of E18 Physical Thing implies the incorporation of physical material, whereas the production of instances of E28 Conceptual Object does not. Similarly, instances of E18 Physical Thing cease to exist when destroyed, whereas an instance of E28 Conceptual Object perishes when it is forgotten or its last physical carrier is destroyed.

Transitivity

CIDOC CRM is formulated as a class system with inheritance. A property P with domain A and range B will also be a property between any possible subclasses of A and of B. In many cases there will be a common subclass C of both A and B. In these cases, when the property is restricted to C, that is, with C as domain and range, the restricted property could be transitive. For instance, an E73 Information Object can be incorporated into an E90 Symbolic Object and thus an information object can be incorporated in another information object.

In the definition of CIDOC CRM the transitive properties are explicitly marked as such in the scope notes. All unmarked properties should be considered as not transitive.

Introduction to the basic concepts

The following paragraphs explain the most general logic of the CIDOC CRM. The CIDOC CRM is a formalized representation of historical discourse, a formal ontology. In this capacity, it is meant to support the (re)presentation of fact based, analytic discourse about what has happened in the past in a human understandable and machine-processable manner. It achieves this function by proposing a series of formalized properties (relations) and classes. The formalized properties support the making of semantically explicit statements relating classes of things. Their formal definition logically explicates the classes of things to which they may pertain. The CIDOC CRM properties thus enable a formal, logically explicit description of relations between individual, real world items, classified under distinct ontological classes. Encoding analytic data pertaining to the past under such a system of statements provides a standard representation for data and allows the uniform application of reasoning to large sets of data.

Grounding this high level logic is a hierarchical system of classes and relations, that provide basic ontological distinctions by which to represent historical discourse. Familiarity with the basic ontological distinctions made in the top level of the class hierarchy provides the basic entry point to understanding how to apply the CIDOC CRM for knowledge representation.

The highest level distinction in the CIDOC CRM is represented by the top level concepts of E77 Persistent Item, equivalent to the philosophical notion of endurant; E2 Temporal Entity, equivalent to the philosophical notion of perdurant and, further, the concept of E92 Spacetime Volume.

As an event-centric model, supporting historical discourse, the CIDOC CRM firstly enables the description of entities that are themselves time-limited processes or evolutions within the passing of time using E2 Temporal Entity and its subclasses. Their basic function is to capture the fact of something having happened over time. In addition to allowing the description of a temporal duration, the subclasses of E2 Temporal Entity are used to document the historical relations between objects, similar to the role of action verbs in a natural language phrase. The more specific subclasses of E2

Temporal Entity enable the documentation of events pertaining to individually related/affected material, social or mental objects that have been described using subclasses of E77 Persistent Item. This precise documentation is enabled through the use of specialized properties formalizing the manner of the relation or affect. Examples of specific subclasses of E2 Temporal Entity include E12 Production, which allows the representation of events of making things by humans, and E5 Event which allows the documentation, among other things, of geological events and large scale social events such as a war. Each of these subclasses have specific properties associated to them which allow them to function to represent the specific, real world connection between instances of E77 Persistent Item, such as the relation of an object to its time of production through *p108 was produced by* (E12) or the relation of a place to a geological phenomenon through *p7 was place of* (E5). The entities that E2 Temporal Entity documents, being time limited processes / occurrences, are such that their existence can be declared only on the basis of direct observation or recording of the event, or indirect observation of its material outcomes. Evidence of such entities may be preserved on material objects that are permanently changed because of them. Likewise events may have been recorded in text or remembered through oral history. E2 Temporal Entity and its subclasses are central to the CRM and essential for almost all modelling tasks (e.g. in a museum catalogue one cannot consider an object outside its production event).

The real world entities, which the event centric modelling of the CIDOC CRM aims to enable the accurate historical description of, are captured through E77 Persistent Item and its subclasses. E77 Persistent Item is used to describe entities that are relatively stable in form through the passage of time, maintaining a recognizable identity because their significant properties do not change. Specific subclasses of E77 Persistent Item can illustrate this point. E22 Human Made Object is used for the description of discrete, physical objects having been produced by human action, such as an artwork or monument. An artwork or monument is persistent with regards to its physical constitution. So long as it retains its general physical form it is said to exist and to participate in the flow of historical events. E28 Conceptual Object is also used to describe persistent items but of a mental character. It is used to describe identifiable ideas that are named and form an object of historical discourse. Its identity conditions rely in having a carrier by which it can be recalled. The entities described by E77 Persistent Item are prone to change through human activity, biological, geological or environmental processes, but are regarded to continue to exist and be the same just as long as such changes do not alter their basic identity (essence) as defined in the scope note of the relevant class.

Comment (5) to the work done by the editorial group.
The text of the first paragraph marked in yellow is added. The editorial group considers this to be uncontroversial editing. Formally this work is a part of the ISSUE 459: Modelling Principles (Intro to the CRM). The text marked in grey is ok and can be kept as is.

End comment (5)

The notion of identity is key in the application of CIDOC CRM. The properties and relations it provides are designed to allow the accurate historical description of the evolution of real world items through time. This being the case, classes and properties are created in order to provide a definition which will allow the accurate application of the classes or properties to the same real world items by diverse users. Identity, in the sense of the CIDOC CRM, therefore, means that informed people are able to agree that they refer to the same, single thing in its distinction from others, both in its extent and over its time of

existence. The criteria for such a determination should come from understanding the scope note of the respective CIDOC CRM class that this thing is regarded to be an instance of, because communication via information systems may not leave space for respective clarifying dialogues between users. For example, the Great Sphinx of Giza may have lost part of its nose, but there is no question that we are still referring to the same monument as that before the damage occurred, since it continues to represent significant characteristics and distinctness from an overall shaping in the past, which is of archaeological relevance. Things lacking sufficient stability or differentiation, such as atmosphere, soil, clouds, waves, are not instances of E77 Persistent Item, and not suited for information integration. Discourse about such items may be documented with concepts of the CIDOC CRM as observations in relation to things of persistent identity, such as places.

Learning to distinguish and then interrelate instances of E77 Persistent Item (endurants) and instances of E2 Temporal Entity (perdurants) using the appropriate properties is key to the proper understanding and application of CIDOC CRM in order to formally represent analytic historical data. In the large majority of cases, the distinction this provides and the subsequent elaboration of subclasses and properties is adequate to describe the content of database records in the cultural and scientific heritage domain. In exceptional cases, where we need to consider complex combinations of changes of spatial extent over time, the concept of spacetime (E92 Spacetime Volume) also needs to be considered. E92 Spacetime Volume describes the entities whose substance has or is an identifiable, confined geometrical extent in the material world that may vary over time, fuzzy boundaries notwithstanding. For example, the built settlement structure of the city of Athens is confined both from the point of view of time-span (from its founding until now) and from its changing geographical extent over the centuries, which may become more or less evident from current observation, historical documents and excavations. Even though E92 Spacetime Volume is an important theoretical part of the model, it can be ignored for most practical documentation and modeling tasks.

The key to the proper understanding of CIDOC CRM comes through the appropriation of its basic divisions and the logic these represent. It is important to underline that the CIDOC CRM is not intended to function as a classification system or vocabulary tool. The basic class divisions in CIDOC CRM are declared in order to be able to apply distinct properties to these classes and, in so doing, formulate precise, analytic propositions that represent historical realities The expressive power of CIDOC CRM comes not from the application of classes to classify entities but in the documenting the interrelation of individual historical items through well defined properties. These properties characteristically cover subjects such as relations of *identifying* items by names and identifiers; *participation* of persistent items in temporal entities; *location* of temporal entities and physical things in space and time; relations of *observation* and assessment; part-decomposition and *structural* properties of anything; *influence* of things and experiences on the activities of people and their products; *reference* of information objects to anything.

We explain these concepts with the help of graphical representations in the next sections.

Relations with Events:

Figure 1 illustrates the minimal properties in the CIDOC CRM for documenting "what has happened", the central pattern of the Model. Let us first consider the class *E1 CRM Entity*, the formal top class of the model. It primarily serves a technical purpose to aggregate the ontologically meaningful concepts of the

model. It declares however two important properties of general validity and distinct features of the Model: *P1* is identified by, with range *E41 Appellation,* makes the fundamental ontological distinction between the identity of a particular and an identifier (see section "Reality, Knowledge Bases and CIDOC CRM" above), and in practice allows for describing a discourse about resolving historical ambiguities of names and reconciliation of multiple identifiers. The property *P2 has type*, with range *E55 Type*, constitutes a practical interface for refining classes by terminologies, being often volatile, as detailed in the section "About Types" below.
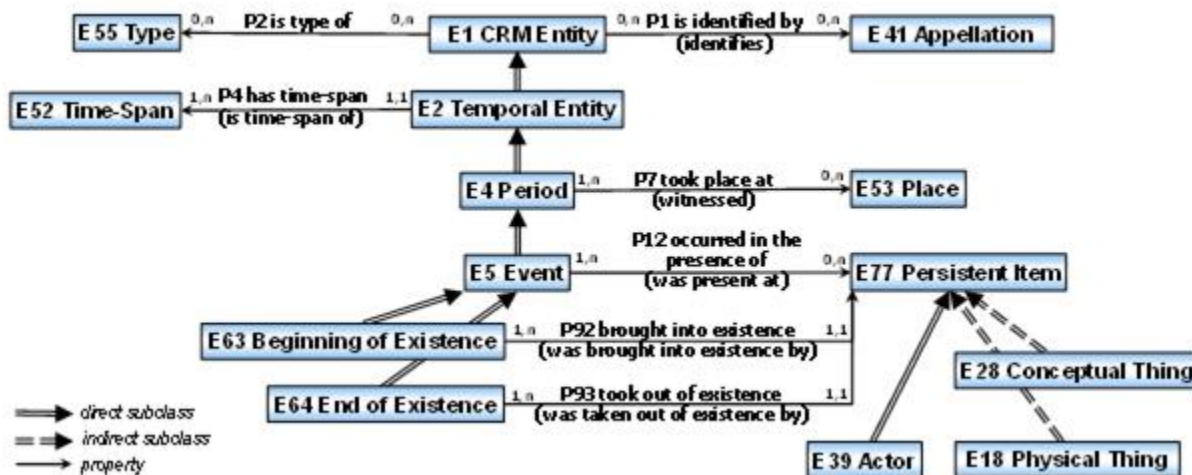

Figure 1: *properties of basic concepts*

All classes in figure 1 are direct or indirect subclasses of *E1 CRM Entity,* but for better readability, only the "subclass of" -link from *E2 Temporal Entity* is shown. The latter comprises phenomena that continuously occur over some time-span (*E52 Time-Span*) in the natural time dimension, but some of them may not be confined to specific area, such as a marriage status[11]. Further specializing, *E4 Period* comprises phenomena occurring in addition within a specific area in the physical space, which can be specified by *P7 took place at*, with range *E53 Place*. Instances of *E4 Period* can be of any size, such as the Warring States Period, the Roman Period, a siege or just the process of making a signature. Further specializing, *E5 Event* comprises phenomena involving and affecting certain instances of *E77 Persistent Item* in a way characteristic of the kind of process, which can be specified by the property *P12 occurred in the presence of*. This concept of presence is very powerful: It constrains the existence of the involved things to the respective places within the specified time and implies the potential of passive or active involvement and mutual impact. Via presence, events represent nodes in a network of things meeting in various combinations in the course of time at different places.

The most important specializations of *E77 Persistent Item* in this context are: *E39 Actor*, those capable of intentional actions, *E18 Physical Thing*, having an identity bound to a relative stability of material form, and *E28 Conceptual Object,* the idealized things that can be recognized but have an identity independent from the materialization on a specific carrier. The property *P12 occurred in the presence of*

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has 36 direct and indirect subproperties, relating these and many more subclasses of *E5 Event* and *E77 Persistent Item.* Regardless whether a CRM-compatible knowledge base is created with these properties only or with their much more expressive specializations, querying for the above presented five properties will provide answer to all "Who-When-Where-What-How" questions, and allow for retrieving potentially richly elaborated stories of people, places, times and things.

This pattern of "meeting" is complemented by two more subclasses of *E5 Event*: *E63 Beginning of Existence* and *E64 End of Existence*, which imply not only presence, but constitute the **endpoints of existence** of things and people in space and time, often in explicit presence and interaction with others, be they causal by producing or consuming or just witnessing, Note that the Model supports multiple instantiation. As a consequence particular events can be instances of combinations of these and others classes, describing tightly integrated processes of multiple nature. The representation of things connected in events by presence, beginning and end of existence is sufficient to describe the logic of *termini postquos and antequos*, a major form of reasoning about chronology in historical studies.
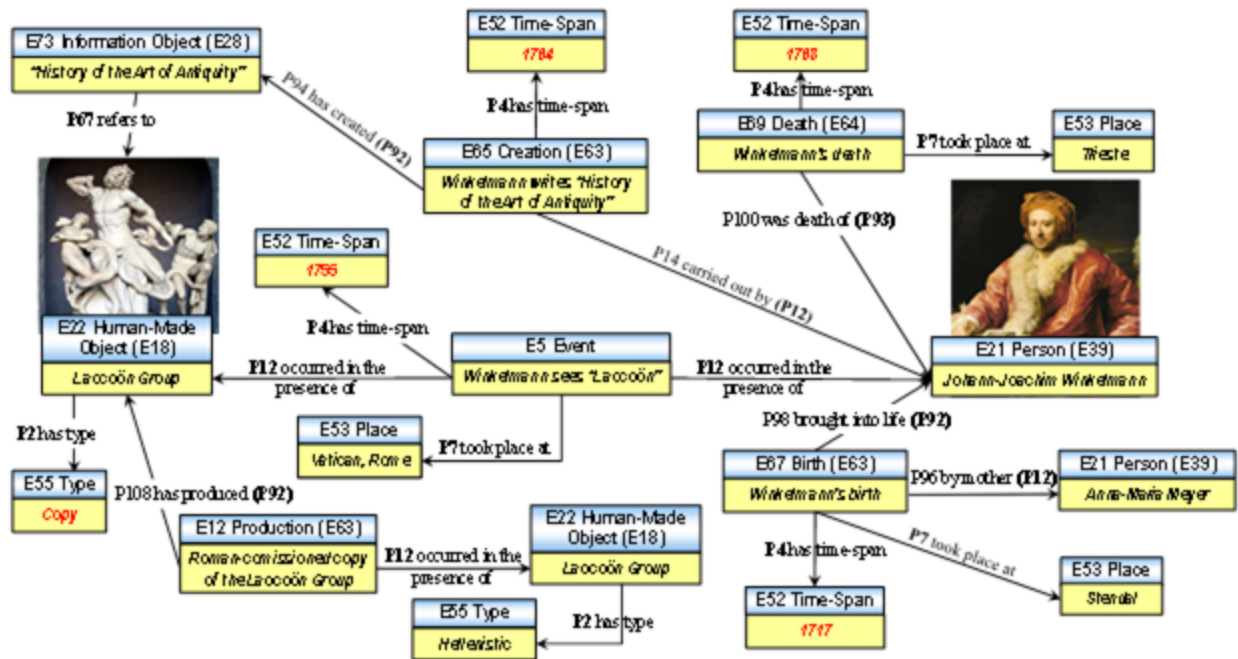
Figure 2: *CRM encoding example: Winkelmann seeing Laokoon*

Example:

As a simple, real example of applying the above concepts we present a historical event, relevant for the history of art: Johann-Joachim Winkelmann (a German Scholar) has seen the so-called Laocoön Group in 1755 in the Vatican in Rome (at display in the Cortile del Belvedere). He described his impressions in 1764 in his "History of the Art of Antiquity", (being the first to articulate the difference between Greek,

Greco-Roman and Roman art, characterizing Greek art with the famous words "…noble simplicity, silent grandeur"). The sculpture, in Hellenistic "[Pergamene](#) baroque" style, is widely assumed to be a copy, made between 27 BC and 68 AD (following a Roman commission) from a Greek (no more extent) original. Johann-Joachim Winkelmann was born 1717 as child of Martin Winkelmann and Anna-Maria Meyer and died in 1768 in Trieste.

Figure 2 presents a semantic graph of this event, as described above, using CIDOC CRM concepts. The facts in parentheses above are omitted for better clarity. Instances of classes are represented by informative labels instead of identifiers, in boxes showing the class label above the instance label. Properties are represented as arrows with the property label attached. After class labels and property labels we show in parenthesis the identifiers of the respective superclasses and superproperties from figure 1, in order to demonstrate that the story can be represented and queried with these concepts only. It also shows how concept specialization increases expressiveness without losing genericity. It is noteworthy that the transfer of information from the Greek original, to the copy, to the mind of Winkelmann and into his writings can be understood solely by this chain of things *being present* in different meetings. Note also that the degree to which a fact is believed to be real does not affect the choice of CIDOC CRM concepts for description of the fact, nor the reality concept underlying the Model.

Figure 2 represents in addition one more top-level property of the CIDOC CRM: *P67 refers to*, which describe an evidence-based fact that an information object makes reference to an identifiable item.
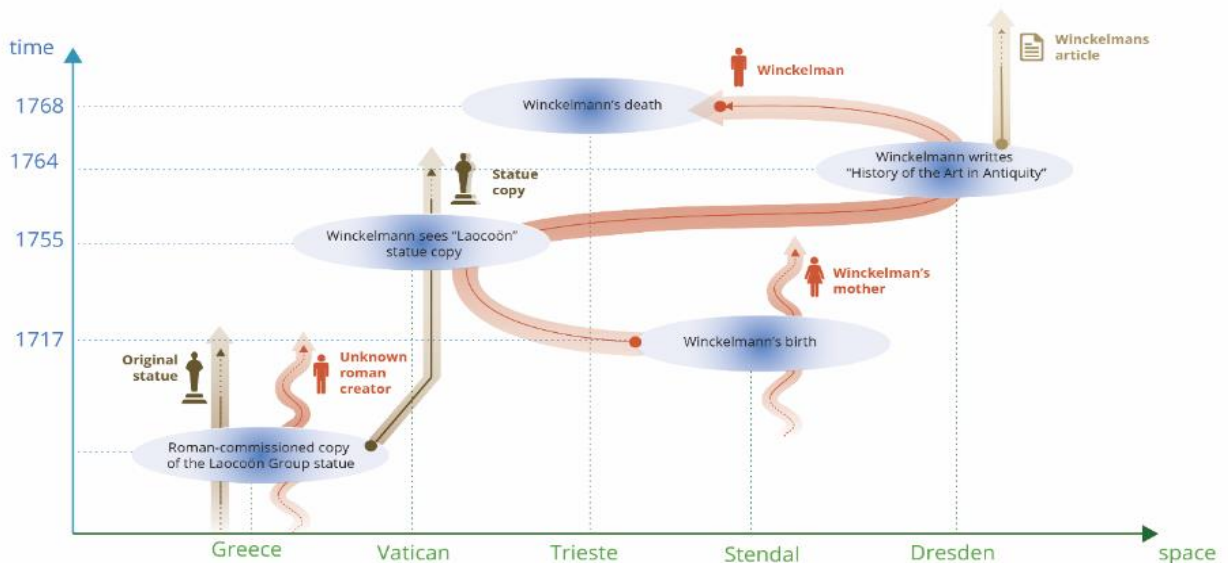

Figure 3: *Symbolic representation of "Winkelmann seeing Laocoon" as an evolution in space and time*

In the following, we give an overview of the system of spatial and temporal relations in the CIDOC CRM, because it constitutes an important tool for precise documentation of the past and has a certain complexity that needs to be understood in a synopsis.

Note from the minutes. This is figure 3 depicting how the paths of Winkelmann and the statue of Laocoon cross in space and time (i.e. how the spacetime volumes of Winkelmann and Laocoon's statue meet) The following figure 3 needs better visualization. HW have been assigned to Matteo Lorenzini for improving the figure 3.

Spatial Relations

A major area of documentation and historical research centres around positioning in space of what has happened and the things involved, as well as reasoning about respective spatial relations. The key class CIDOC CRM provides for modeling this information is *E53 Place*. *E53 Place* is used to document geometric extents in the physical space containing actual or possible positions of things or happenings. The higher level properties and classes of CIDOC CRM that centre around *E53 Place* allow for the documentation of: relations between places, recording the geometric expressions defining or approximating a place and their semantic function, tracing the history of locations of a physical object, identifying the places where an individual or group have been located, identifying places on a physical object and the spatial extent of certain temporal entities.

Relations between Places: The cluster of relations *P89 falls within (contains)*, *P122 borders with*, *P121 overlaps with* and *P189 approximates* can express relative relationships held between places. These properties hold between instances of *E53 Place* and allow interordering places using common mereotopological concepts.

Geometric Expressions of Place: Contemporary documentation of spatial information has access to advanced equipment for accurately recording location and libraries of georeferenced place information. For this reason, documentation of place now often includes the recording of precise coordinates for a referenced place. Of great importance semantically, is to understand the manner in which such a geometric place expression actually relates to a referenced place. The cluster or relations *P168 place is defined by*, *P171 at some place within*, and *P172 contains* allows the user to link to geometric place expressions while also accurately indicating how this expression relates to the documented place. Geometric place expressions are instances of *E94 Space Primitive*, a primitive class for expressing values in data systems not further analyzed in the CIDOC CRM. These properties provide a valid interface to the OGC standards, as elaborated in CRMgeo (Doerr and Hiebel 2013).

History of Object Locations: Instances of place are often referenced in order to record the location of some object. When the movement of the object to different locations through time is of interest, it is also important to be able to analytically record the different locations at which an object was and at what point. The CIDOC CRM offers two top level mechanisms for tracing the relation of objects to places. If the aspect of time is unknown or not of interest, then an object can be related to a place through the properties *P53 has former or current location* and *P55 has current location*. The former property is the conservatively appropriate choice for documenting the object-to-place relation when time elements are not known. If one is actively tracking current location, the latter property is also of use. When an accurate history of the temporal aspect of location should be provided, the user should take advantage of the *E9 Move* class, a temporal entity class. Instantiating *E9 Move* allows the user to document the origin, destination and concerned object of a move event using the collection of properties *P27 moved from*, *P26 moved to*, *P25 moved*. Being a temporal class *E9 Move* further allows

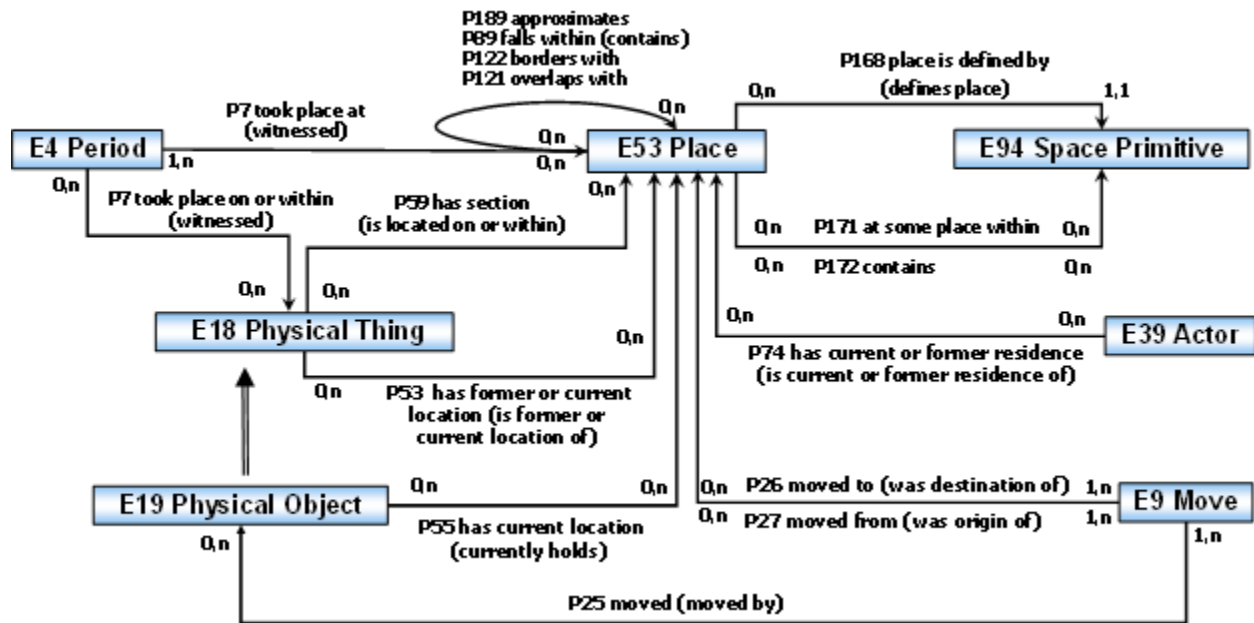the tracing of time, agency etc. Note that things may be moved indirectly as parts of or within other things.

Figure 4: *reasoning about spatial information*

Actor Locations: Tracking the history of the location of actors is related to the history of object location with a significant difference: in the CIDOC CRM an actor is defined as an entity featuring agency which is not the case in objects and physical entities in general. Not being physical, an actor cannot be the subject of *E9 Move* which documents physical relocations. The CIDOC CRM thus offers the notion of *P74 has current or former residence* in order to document the relation of a person or group to a location as residing there at some time.

Places on a Physical Object: In the recording of cultural heritage and other scientific data, particularly about mobile objects, including ships, it is often necessary to identify where on an object or a certain feature is located and where a certain phenomenon is observed. For this the CIDOC CRM offers the relation *P59 has section* relating the object to the places which are defined upon it. Note that Earth is the physical object we relate places to per default. In geological times, a narrower relation to a tectonic plate may be necessary.

Spatial Extent of Temporal Entities: In order to spatially define the extent of temporal phenomena, the CIDOC CRM offers two properties that apply to all instances of temporal entity under the class *E4 Period*: *P7 took place at* and *P8 took place on or within*. The former is used to relate a temporal phenomenon directly to an instance of *E53 Place* which provides the geometric context in which that phenomenon took place. The latter property allows the documentation of a temporal phenomenon taking place in relation to a physical object. This is useful for recording information such as the occurrence of an event

on a moving ship or within a particular storage container, where the geometric location is not known or indirectly relevant.

Temporal Relations

Historical and scientific discourse about the past deals with different levels of knowledge regarding events and their temporal ordering that feed into chronology. Chronology is fundamental to understanding social and natural history, and reasoning about temporal relations and causality is directly related. An immense wealth of physical observations allows for inferring temporal relations and vice-versa. It is important to be able to document temporality both with regards to known dates but also according to relative positioning within a historical time line. The top level properties of the CIDOC CRM relating to temporal entities support the documentation of: dates as time spans or dimensions, mereological relations between temporal entities as well as a complete suite of topological relations.

Dates and Durations: When some absolutely dates limiting a temporal entity are known, this can be documented by instantiating the *P4 has time-span* property and creating an instance of *E52 Time-span*. Dates should then be recorded as instances of *E61 Time Primitive* and related to the time-span through properties *P81 ongoing throughout* or *P82 at some time within*. Time is recorded as a span and not an instant in the CIDOC CRM. The choice of property *P81 ongoing throughout* allows the documentation of knowledge that a temporal phenomenon was occurring at least at all points of a known time span. The property *P82 at some time within* allows the weaker claim that the phenomenon must have occurred within the limits of a particular time span without further specifying as to when precisely. It is the default for historical dates, given, for instance, in years for events of much smaller duration. The actual mode of encoding the documented date is outside the scope of the CIDOC CRM, which defines this with a primitive class, *E61 Time Primitive*. Finally, the property *P191 had duration* can be deployed in order to document a temporal phenomenon with known duration but with less precisely temporal positioning. For instance, a birth may be known with the precision of a year, but with a duration of 3 hours. For documenting exact time-spans that are result of a declarations rather than observation, for instance in order to describe a time-span multiple events may fall into, the property *P170 defines time* allows for specifying the time-span uniquely by a temporal primitive, rather than by *P81 ongoing throughout* or *P82 at some time within* using an identical time primitive.
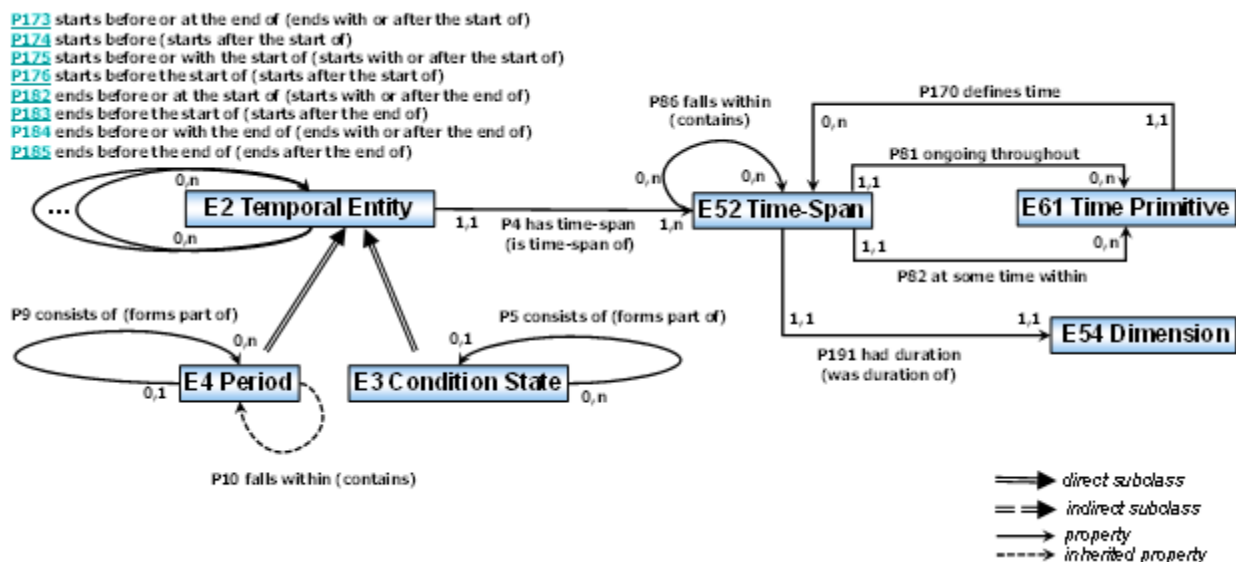
Figure 5: *reasoning about temporal information*

Mereological relations: The documentation of the part-whole relationship of temporal phenomena is crucial for historical reasoning. The CIDOC CRM distinguishes under temporal entities two immediate specializations: *E4 Period* is a high-level concept for the documentation of temporal phenomena of change and interactions in space and time, comprising but not limited to historical periods such as Ming or Roman, and is further specialized in rich hierarchy of more specific processes and activities. The second specialization is *E3 Condition State,* a rather specific class for the documentation of static phases of physical things. The CIDOC CRM so far does not describe a higher level class of static phases, because they are normally deductions from multiple observations, problematic in information integration and vulnerable to non-monotonic revision. For both classes, two different mereological relations are articulated: The property *P9 consists of* is used to document proper parthood between instances of *E4 Period*, i.e., to describe how the phenomena that make up an instance of *E4 Period* can causally be subdivided into more delimited phenomena. In contrast, the property *P10 falls within*, explained further in the section about spatiotemporal relations, describes only a non-causal co-occurrence in the same spatiotemporal extent. The property *P5 consists of* indicates, in analogy, proper parthood between instances of *E3 Condition State*.

Topological Relations: A lot of semantic relations have implications on the temporal ordering of temporal entities. For instance, meeting someone must occur after birth and before death of the involved parties. Information can only be transferred after it has been learned. On the other side, direct information about temporal order has implications on possible or impossible semantic relations. This form of reasoning is of paramount importance for research about the past. It turned out that the popular temporal relations defined by (J. Allen 1983), which the CIDOC CRM had adopted in previous versions, are not well suited to describe inferences from semantic relations, as detailed in the section "Temporal Relation Primitives based on fuzzy boundaries" below. Instead, the CIDOC CRM introduces a theory of fuzzy boundaries in time that enables the accurate interpositioning of temporal entities between themselves taking into account the inherent fuzziness of temporal boundaries. This model subsumes the earlier introduced Allen temporal relations which may continued to be used in extensions of the CIDOC CRM.

Spatiotemporal Relations
Treating space and time as separate entities is normally adequate for describing events and where things are. When more precise documentation and reasoning is required about phenomena spreading out over time, such as Bronze Age, a settlement, a nation, moving reference frames such as ships, things being stored in containers and moved around, built structures being partially destroyed, rebuilt and altered etc., space and time must be understood as a coherent continuum, the so-called spacetime. This is not a familiar concept for many users, and those not interested in such details may therefore skip this section.

Figure 6: *reasoning with spacetime volumes*

However the respective model the CIDOC CRM adopts constitutes a valid interface to the OGC standards, as elaborated in CRMgeo (Doerr and Hiebel 2013) and important for connecting to GIS applications. The key class CIDOC CRM provides for modeling this information is *E92 Spacetime Volume*. *E92 Spacetime Volume* is used to document geometric extents in the physical spacetime containing actual or possible positions of things or happenings, in particular in those cases when the changes of place to be documented cannot be reduced to distinct events, because the spatial extent changes continuously. The higher level properties and classes of CIDOC CRM that centre around *E92 Spacetime Volume* allow for the documentation of: relations between spacetime volumes, relations to space and time as separate entities, and treating the exact extent of physical things and periods in space at any time of their existence as spacetime volumes. Its use is particularly elegant for the description of temporal gazetteers.

Defining a Spacetime Volume: There are three ways to define a spacetime volume:

(1) the property *P169 defines spacetime volume* should be used to declare a spatiotemporal container for some things or happenings in terms of spatial coordinates that may vary over time, be it in discrete steps or continuously with the help of spacetime expressions. The latter are instances of *E95 Spacetime Primitive*, a primitive class for expressing values in data systems not further analyzed in the CIDOC CRM.

(2) Instances of *E4 Period* are regarded to be specialized instances of *E92 Spacetime Volume* that are formed by the spreading out of the phenomena that make up an instance of E4 Period. As such they are fuzzy but in general observable.

(3) The continuous sequence of spatial extent that the matter of an instance of E18 Physical Thing occupies in the course of time, defines a spacetime volume unique to it from the beginning of its existence to its end, which can also be understood as its trajectory through the universe The property *P169 defines* allows for referring to this spacetime volume, in order to document its additional properties. As such this spacetime volume is fuzzy but in general observable. It is not easy to make a mental picture of the spacetime volume of a physical thing, but the construct simplifies all reasoning

about where things have been.

Relations with Places and Physical Things: The property *P161 has spatial projection* associates a spacetime volume with the complete spatial extent it has occupied during its time-span of definition. Due to relativity of space, the definition of an instance of E53 Place must be relative to some physical thing as geometric reference. This can explicitly be documented with the property *P157 is at rest relative to*. If the place where something is at a certain point in time is given in multiple reference spaces in relative movement, such as with respect to a ship versus to the seafloor, these differently defined places may later move apart. Therefore, a spacetime volume, even though uniquely defined, can have any number of spatial projections, depending on the reference space. Currently, the GPS system defines a default reference space on the surface of Earth. In art conservation and other descriptions of mobile object of fixed shape, it is useful to refer to the precise place a physical thing occupies with respect to itself as reference space via *P156 occupies*, for further analysis. *P156 occupies* constitutes a particular projection of the spacetime volume of this thing. In contrast, the property *P53 has former or current location* only describes that a thing was within a specific place given in some reference space for an undefined time.

Relations with Time-Spans and Periods: The property *P160 has temporal projection* associates a spacetime volume with the complete temporal extent it has covered comprising all places of its definition. In contrast to places, the reference system of time is unique[12] except for the choice of origin. For instances of E4 Period and its subclasses, which inherit *P160 has temporal projection,* the property is actually identical with the property *P4 has time span* inherited from *E2 Temporal Entity,* because is describes the temporal extent of the phenomena that make up an instance of E4 Period. Therefore it is recommended to use *P4 has time span* for instances of E4 Period and its subclasses, rather than *P160 has temporal projection*.

Relations of Presence: Instances of *E93 Presence* are specialized instances of *E92 Spacetime Volume* that are identical with the spatial evolution of a larger spacetime volume specified by *P166 was presence of*, but delimited to a, normally short, time-span declared by *P164 during*. In other words, they constitute "snapshots" or "time-slices" of another spacetime volume, such as the extent of the Roman Empire during 30AD. They are the basic construct to describe exactly where something was or happened at a particular time (-span), in connection with the property *P161 has spatial projection.* In particular, it allows for describing the whereabouts of mobile objects, be it in the storage of a museum, a palace, deposited in the ground, or transported in a container, such as the bone of a saint. For ease of use, a shortcut *P195 was presence of* is defined directly to E18 Physical Thing, bypassing the definition of its spacetime volume.

Topological Relations: Finally the Model defines truly spatiotemporal topological relations. *P10 falls within (contains)* is the complete inclusion of one spacetime volume in another. It should not be confused with inclusion in the spatial and temporal projection, which may be larger. E.g. in 14 AD, Mesopotamia was not within the Roman Empire. Further, the properties *P132 spatiotemporally overlaps with* and its negation *P133 is spatiotemporally separated from* are fundamental to argue about temporary parthood, possible continuity etc.

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[12] This holds for applications in the scope of the CIDOC CRM, which are in the non-relativistic area, but not strictly, for instance, for satellites.

Specific Modelling Constructs

Virtually all structured descriptions of museum objects begin with a unique object identifier and information about the "type" of the object, often in a set of fields with names like "Classification", "Category", "Object Type", "Object Name", etc. All these fields are used for terms that declare that the object belongs to a particular category of items. In the CIDOC CRM the class E55 Type comprises such terms from thesauri and controlled vocabularies used to characterize and classify instances of CIDOC CRM classes. Instances of E55 Type represent concepts (universals) in contrast to instances of E41 Appellation, which are used to name instances of CIDOC CRM classes.

For this purpose the CIDOC CRM provides two basic properties that describe classification with terminology, corresponding to what is the current practice in the majority of information systems. The class E1 CRM Entity is the domain of the property P2 has type (is type of), which has the range E55 Type. Consequently, every class in the CIDOC CRM, with the exception of E59 Primitive Value, inherits the property P2 has type (is type of). This provides a general alternative mechanism to specialize the classification of CIDOC CRM instances to any level of detail, by linking to external vocabulary sources, thesauri, classification schemas or ontologies.

Analogous to the function of the P2 has type (is type of) property, some properties in the CIDOC CRM are associated with an additional property. These are numbered in the CIDOC CRM documentation with a '.1' extension. The range of these properties of properties always falls under E55 Type. The purpose of a property of a property is to provide an alternative mechanism to specialize its domain property through the use of property subtypes declared as instances of E55 Type. They do not appear in the property hierarchy list but are included as part of the property declarations and referred to in the class declarations. For example, P62.1 mode of depiction: E55 Type is associated with E24 Physical Man-made Thing. P62 depicts (is depicted by): E1 CRM Entity.

The class E55 Type also serves as the range of properties that relate to categorical knowledge commonly found in cultural documentation. For example, the property P125 used object of type (was type of object used in) enables the CIDOC CRM to express statements such as "this casting was produced using a mould", meaning that there has been an unknown or unmentioned object, a mould, that was actually used. This enables the specific instance of the casting to be associated with the entire type of manufacturing devices known as moulds. Further, the objects of type "mould" would be related via P2 has type (is type of) to this term. This indirect relationship may actually help in detecting the unknown object in an integrated environment. On the other side, some casting may refer directly to a known mould via P16 used specific object (was used for). So a statistical question to how many objects in a certain collection are made with moulds could be answered correctly (following both paths through P16 used specific object (was used for) - P2 has type (is type of) and P125 used object of type (was type of object used in). This consistent treatment of categorical knowledge enhances the CIDOC CRM's ability to integrate cultural knowledge.

Types, that is, instances of E55 Type and its subclasses, can be used to characterize the instances of a CIDOC CRM class and hence refine the meaning of the class. A type 'artist' can be used to characterize persons through P2 has type (is type of). On the other hand, in an art history application of the CIDOC

CRM it can be adequate to extend the CIDOC CRM class E21 Person with a subclass E21.xx Artist. What is the difference of the type 'artist' and the class Artist? From an everyday conceptual point of view there is no difference. Both denote the concept 'artist' and identify the same set of persons. Thus in this setting a type could be seen as a class and the class of types may be seen as a metaclass. Since current systems do not provide an adequate control of user defined metaclasses, the CIDOC CRM prefers to model instances of E55 Type as if they were particulars, with the relationships described in the previous paragraphs.

Users may decide to implement a concept either as a subclass extending the CIDOC CRM class system or as an instance of E55 Type. A new subclass should only be created in case the concept is sufficiently stable and associated with additional explicitly modelled properties specific to it. Otherwise, an instance of E55 Type provides more flexibility of use. Users that may want to describe a discourse not only using a concept extending the CIDOC CRM but also describing the history of this concept itself, may choose to model the same concept both as subclass and as an instance of E55 Type with the same name. Similarly it should be regarded as good practice to foresee for each term hierarchy refining a CIDOC CRM class a term equivalent of this class as top term. For instance, a term hierarchy for instances of E21 Person may begin with "Person".

One role of E55 Type is to be the CIDOC CRM's interface to domain specific ontologies and thesauri or less formal terminological systems. Such sets of concepts can be represented in the CIDOC CRM as subclasses of E55 Type, forming hierarchies of terms, i.e. instances of E55 Type linked via P127 has broader term (has narrower term). Such hierarchies may be extended with additional properties. Other standard models, in particular richer ones, used to describe terminological systems can also be interfaced with the CIDOC CRM by declaring their respective concept class as being equivalent to E55 Type, and their respective broader/narrower relation as being identical with P127 has broader term (has narrower term), as long as they are semantically compatible.

In addition to being an interface to external thesauri and classification systems, E55 Type is an ordinary class in the CIDOC CRM and a subclass of E28 Conceptual Object. E55 Type and its subclasses inherit all properties from this superclass. Thus together with the CIDOC CRM class E83 Type Creation the rigorous scholarly or scientific process that ensures a type is exhaustively described and appropriately named can be modelled inside the CIDOC CRM. In some cases, particularly in archaeology and the life sciences, E83 Type Creation requires the identification of an exemplary specimen and the publication of the type definition in an appropriate scholarly forum. This is very central to research in the life sciences, where a type would be referred to as a "taxon," the type description as a "protologue," and the exemplary specimens as "original element" or "holotype".

Finally, instances of E55 Type or suitable subclasses can describe universals from type systems not organized in thesauri or ontologies, such as industrial product names and types, defined and published by the producers themselves for each new product or product variant.

Temporal Relation Primitives based on fuzzy boundaries
It is characteristic for sciences dealing with the past, such as history, archaeology or geology, to derive temporal topological relations from stratigraphic and other observations and from considerations of causality between events. For this reason the CIDOC CRM introduced in version 3.3 the whole set of temporal relationships of Allen's temporal logic (properties P114 to P120). It was regarded at that time as a well-justified, exhaustive and sufficient theory to deal with temporal topological relationships of

spatiotemporal phenomena relevant to cultural historical discourse. Allen's temporal logic is based on the assumption of known, exact endpoints of time intervals (time-spans), described by an exhaustive set of mutually exclusive relationships.

Since many temporal relations can be inferred from facts causal to them, e.g., a birth necessarily occurring before any intentional interaction of a person with other individuals, or from observations of material evidence without knowing the absolute time, the temporal relationships pertain in the CIDOC CRM to E2 Temporal Entities, and not their Time-Spans, which require knowledge of absolute time. If absolute times are known, deduction of Allen's relation is a simple question of automated calculus and not the kind of primary scientific insight the CIDOC CRM, as a core model, is interested in. However, their application turned out to be problematic in practice for two reasons:

Firstly, facts causal to temporal relationships result in expressions that often require a disjunction (logical OR condition) of Allen's relationships. For instance, a child may be stillborn. Ignoring states at pregnancy as it is usual in older historical sources, birth may be *equal to* death, *meet* with death or be *before* death. The knowledge representation formalism chosen for the CIDOC CRM however does **not allow** for specifying **disjunctions**, except within queries. Consequently, simple properties of the CIDOC CRM that imply a temporal order, such as *P134 continued*, cannot be declared as subproperties of the temporal relationship they do imply, which would be, in this case: "before, meets, overlaps, starts, started-by, contains, finishes, finished-by, equals, during or overlapped by" (see *P174 starts before the end of*).

Secondly, nature does not allow us to observe equality of points in time. There are three possible interpretations of this impossibility to observe these equality of points.Common to all three interpretations is that they can be described in terms of fuzzy boundaries. The model proposed here is consistent with **all** three of these interpretations.

1. Any observable phenomenon that can be dated has a **natural temporal extent** with **fuzzy boundaries** of **gradual transition** from not existing to definitely existing and then to no longer existing.
2. These fuzzy boundaries can also be interpreted as the time intervals about which experts, even with a complete knowledge of the described phenomenon, may not agree as to whether this phenomenon is already ongoing or not, or still ongoing or not.
3. Under a third interpretation, the fact that an instance of E2 Temporal Entity is ongoing is **not observable** within the fuzzy boundaries.

Consider, for instance, a birth. Extending over a limited and non-negligible duration in the scale of hours it begins and ends gradually (1), but can be given alternative scientific definitions of start and end points (2), and neither of these can be determined with a precision much smaller than on a scale of minutes (3). The fuzzy boundaries **do not** describe the relation of incomplete or imprecise knowledge to reality. Assuming a lowest granularity in time is an approach which does not help, because the relevant extent of fuzziness varies at a huge scale even in cultural reasoning, depending on the type of phenomena considered. The only exact match is between arbitrarily declared time intervals, such as the end of a year being equal to the beginning of the next year, or that "Early Minoan" ends exactly when "Middle Minoan" starts, whenever that might have been.

Consequently, we introduce here a new set of "temporal relation primitives" with the following characteristics:

- It is a minimal set of properties that allows for specifying all possible relations between two time intervals given by their start and end points, either directly, or by conjunction (logical AND condition) of the latter.
- Start and end points are interpreted as "thick" fuzzy boundaries as described above.
- Conditions of equality of end points are relaxed to the condition that the fuzzy boundaries **overlap**. Therefore knowledge of the shape of the fuzzy function is **not** needed.
- All of Allen's relationships can be expressed either directly or by conjunctions of these properties.
- In case of time intervals without or with negligibly short fuzzy boundaries, all of Allen's relationships can exactly be described by adequate conjunctions of these properties.
- No relationship is equal to the inverse of another. Inverses are specified by exchanging the roles of domain and range.

Notation

We use the following notation:

Comparing two instances of E2 Temporal Entity, we denote one with capital letter A, its (fuzzy) starting time with A^{start} and its (fuzzy) ending time with A^{end}, such that $A = [A^{start}, A^{end}]$; we denote the other with capital letter B, its (fuzzy) starting time with B^{start} and its (fuzzy) ending time with B^{end}, such that $B = [B^{start}, B^{end}]$.

We identify a temporal relation with a predicate name (label) and define it by one or more (in)equality expressions between its end points, such as:

A *starts before the end of* B if and only if ($\equiv$) $\mathbf{A^{start} < B^{end}}$

We visualize a temporal relation symbolizing the temporal extents of two instances A and B of E2 Temporal Entity as horizontal bars, considered to be on an horizontal time-line proceeding from left to right. The fuzzy boundary areas are symbolized by an increasing/decreasing color gradient. The different choices of relative arrangement the relationship allows for are symbolized by two extreme allowed positions of instance A with respect to instance B connected by arrows. The reader may imagine it as the relative positions of a train A approaching a station B. If the relative length of A compared to B matters, two diagrams are provided.
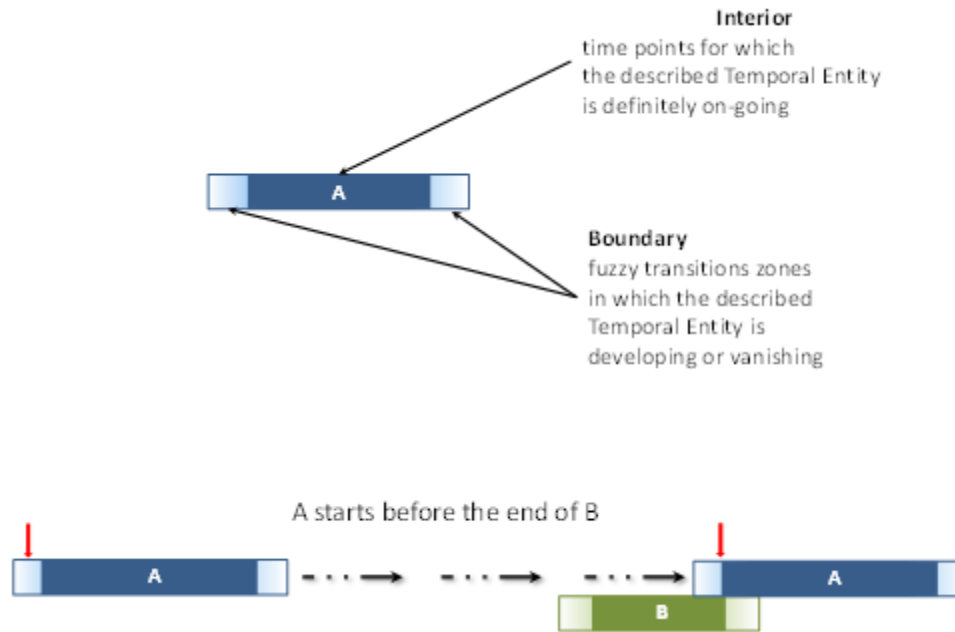
Figure 7: *caption?????*

Overview of Temporal Relation Primitives

The final set of temporal relation primitives can be separated into two groups:

1) Those based on improper inequalities, such as $A^{start} \leq B^{end}$ (odd number items in the list below- table 1)

2) Those based on proper inequalities, such as $A^{start} < B^{end}$ (even number items in the list below- table 1).

Improper inequalities with fuzzy boundaries are understood as extending into situations in which the fuzzy boundaries of the respective endpoints may overlap. In other words, they include situations in which it cannot be decided when one interval has ended and when the other started, but there is no knowledge of a definite gap between these endpoints. In a proper inequality with fuzzy boundaries, the fuzzy boundaries of the respective endpoints must not overlap, i.e., there is knowledge of a definite gap between these endpoints, for instance, a discontinuity between settlement phases based on the observation of archaeological layers.

1. **P173 starts before or with the end of**
   - $A^{start} \leq B^{end}$
2. **P174 starts before the end of**
   - $A^{start} < B^{end}$
3. **P175 starts before or with the start of**
   - $A^{start} \leq B^{start}$
4. **P176 starts before the start of**
   - $A^{start} < B^{start}$
5. **P182 ends before or with the start of**
   - $A^{end} \leq B^{start}$

6. **P183 ends before the start of**
   - ○ $A^{end} < B^{start}$
7. **P184 ends before or with the end of**
   - ○ $A^{end} \leq B^{end}$
8. **P185 ends before the end of**
   - ○ $A^{end} < B^{end}$

Table 1, temporal relation primitives without inverse labels