Standardizing infrastructure for temporal reasoning

CAA SIG Chrono 12 May 2026

Ryan Shaw, University of North Carolina

Incomplete, uncertain, and approximate historical dates

Date formats

XML Schema Definition (XSD) Datatypes

xsd:date (ISO 8601-1)	`1619-08-20`
xsd:integer	`1619`
xsd:gYear	`1619`
xsd:gMonth	`--08`
xsd:gDay	`---20`
xsd:gYearMonth	`1619-08`
xsd:gMonthDay	`--08-20`

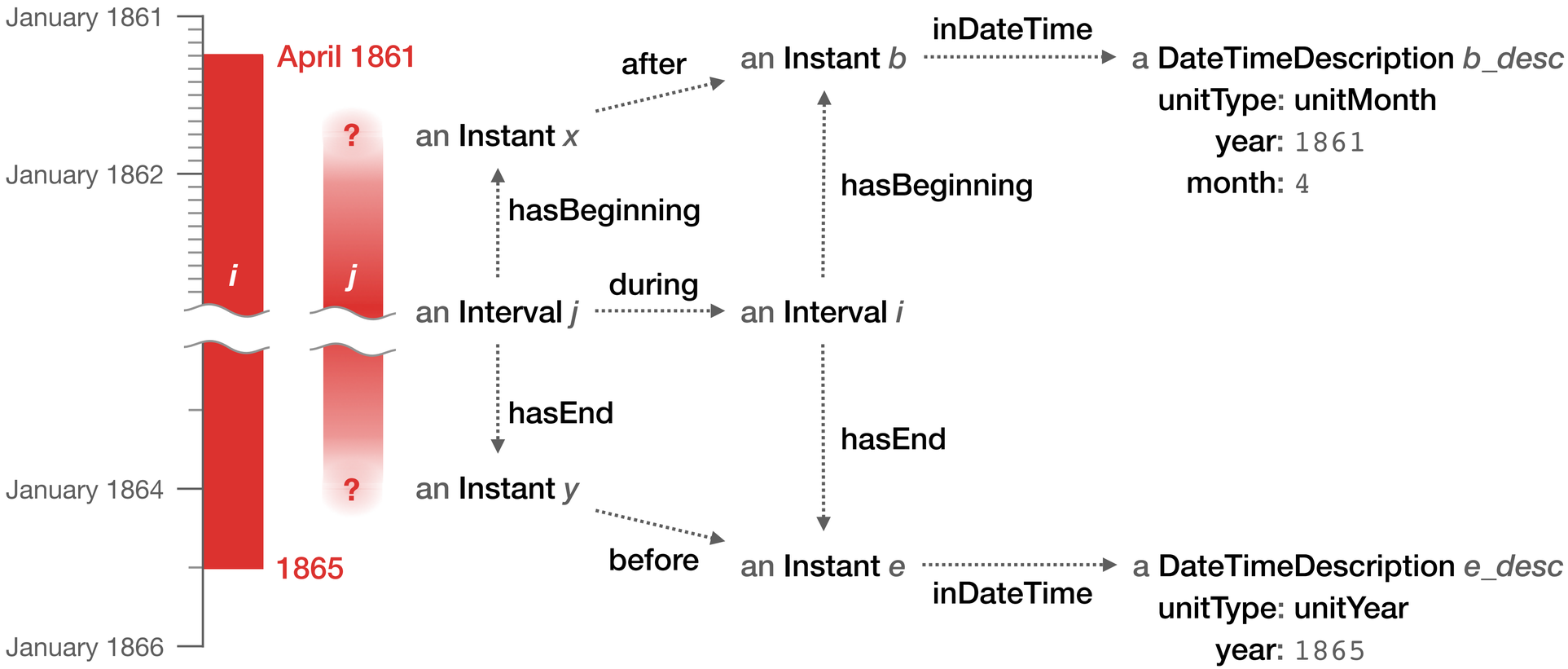
Extended Date/Time Format (EDTF)

https://www.loc.gov/standards/datetime/ (ISO 8601-2)

`1861-04-12/1865-05-09`
`Y-170000000`
`1619-08-XX`
`1619-08-20?`
`1865/..`
`[1667,1668,1670..1672]`
`{1960,1961-12}`

Time Ontology in OWL (OWL-Time)

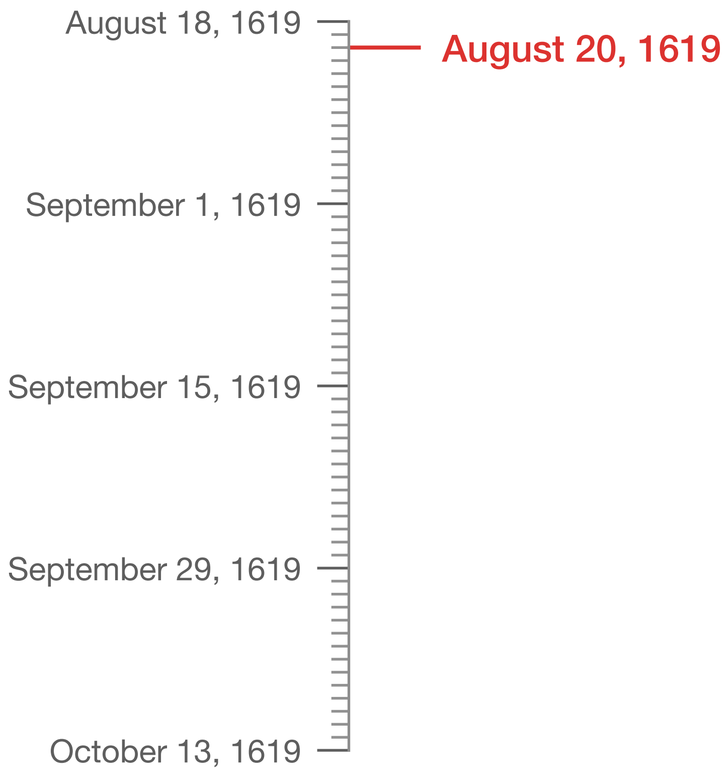
https://www.w3.org/TR/owl-time/



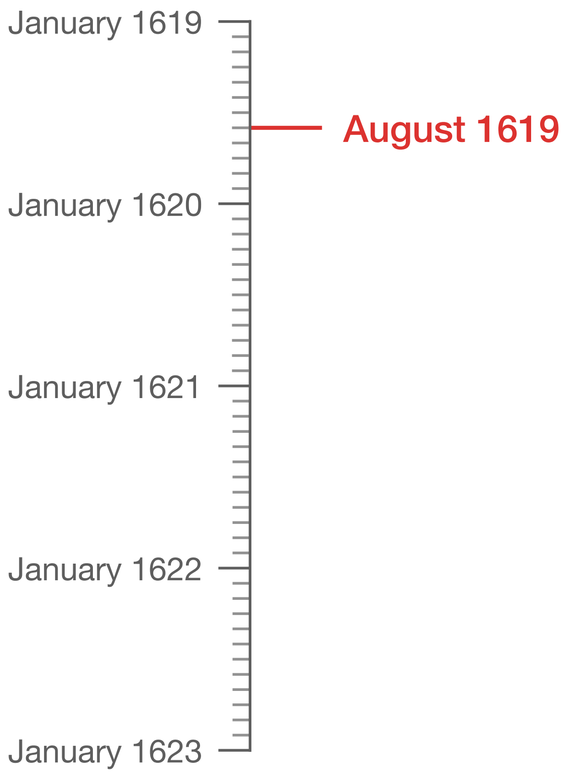
EDTF Level 0

Date precision

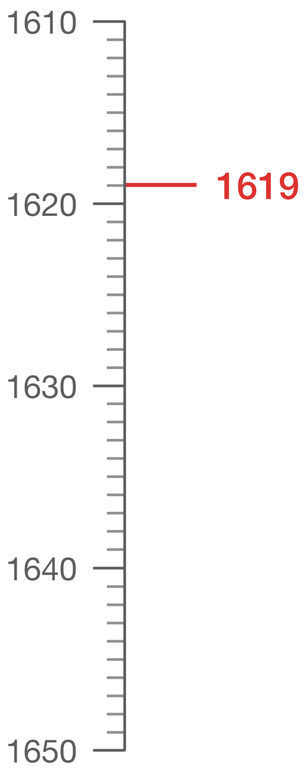
EDTF Level 0



Day precision



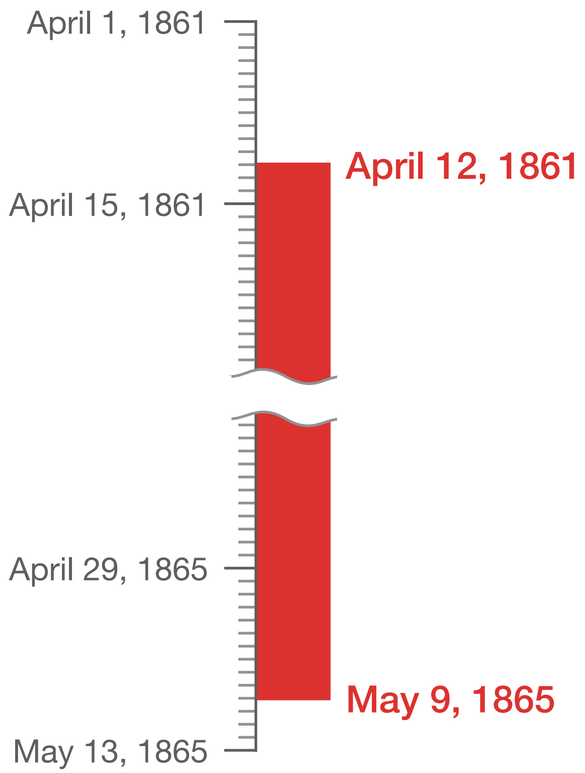
Month precision



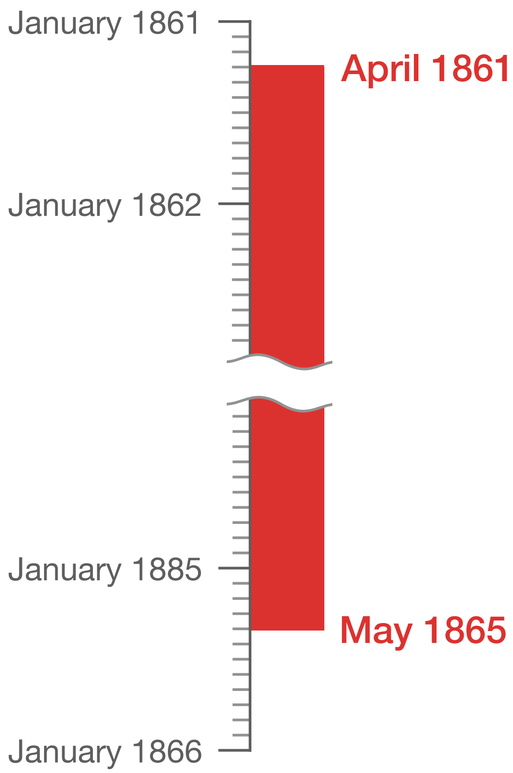
Year precision

Intervals

EDTF Level 0



Day precision



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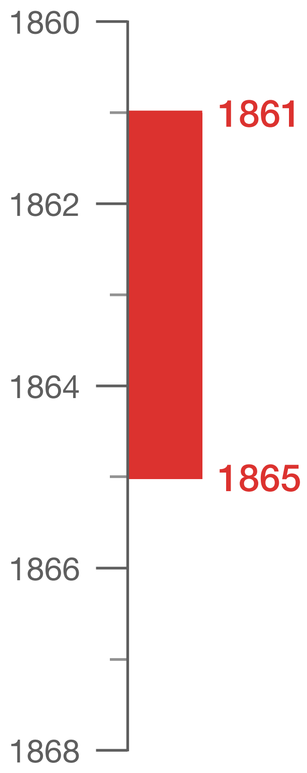
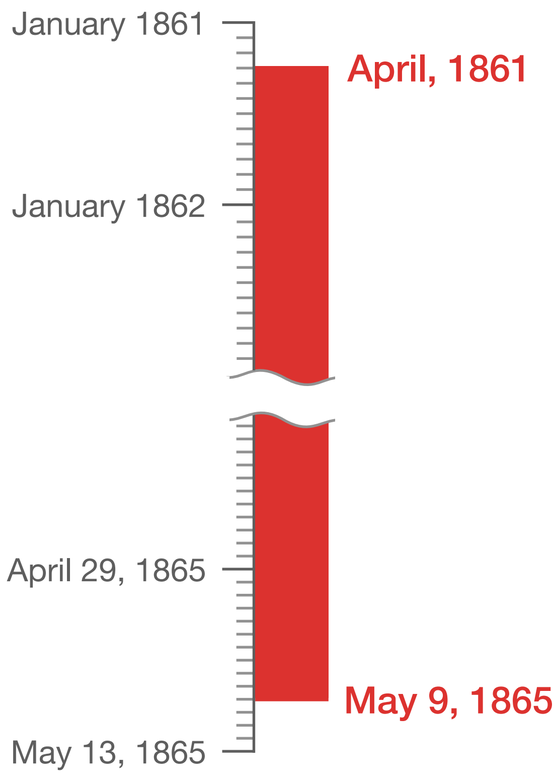
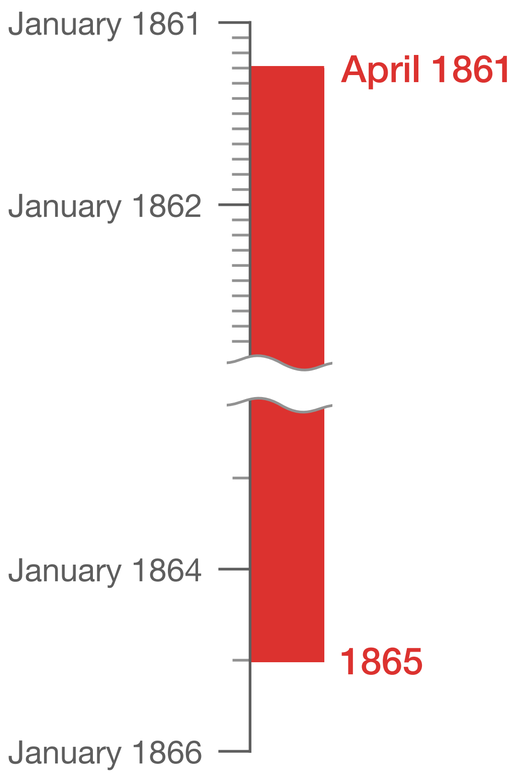


Year precision

Intervals

EDTF Level 0





Mixed precision

Time Ontology in OWL (OWL-Time)

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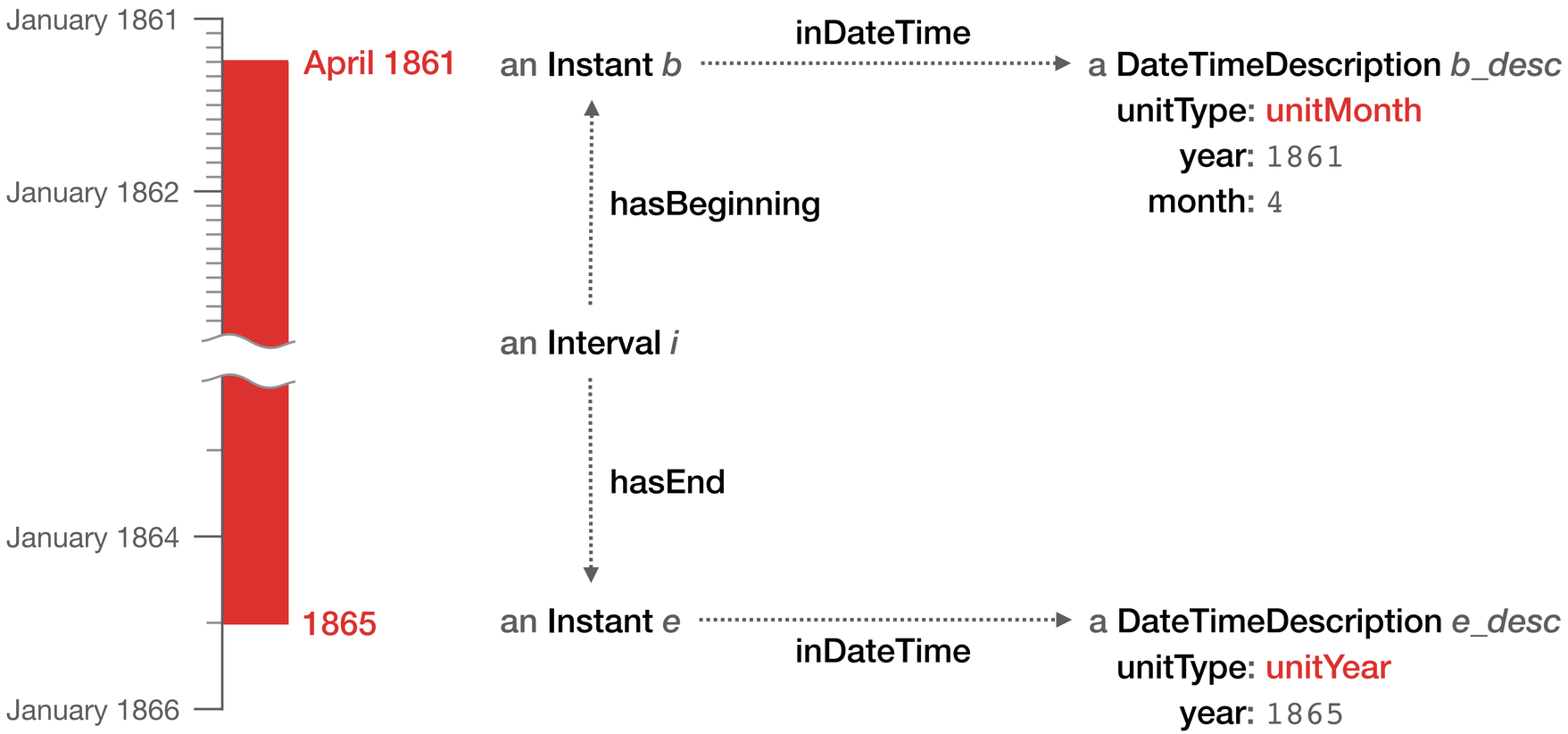

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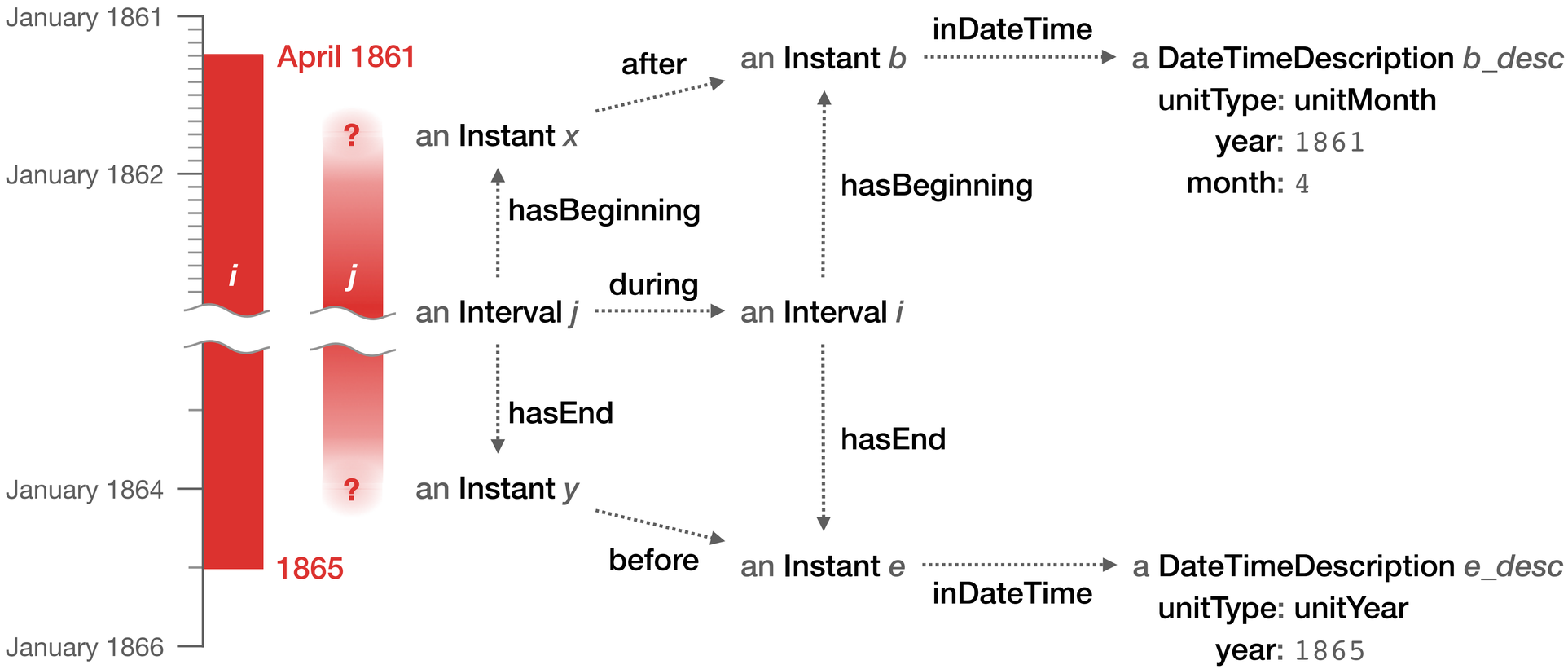

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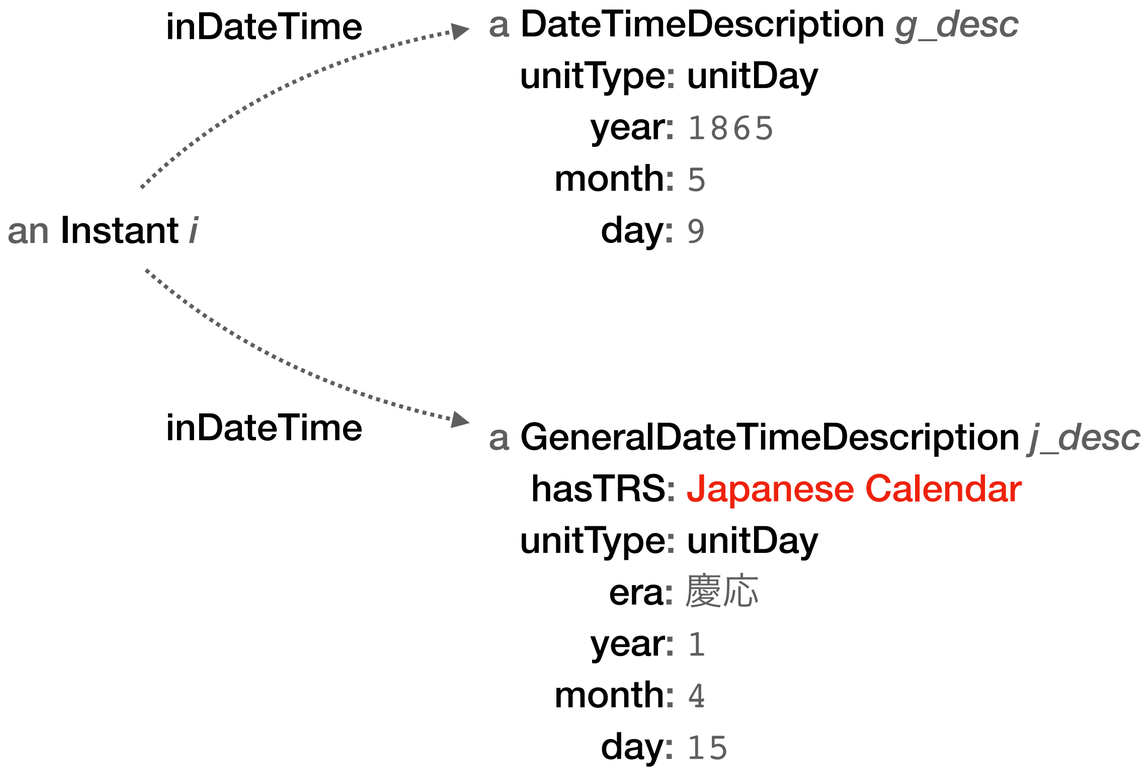
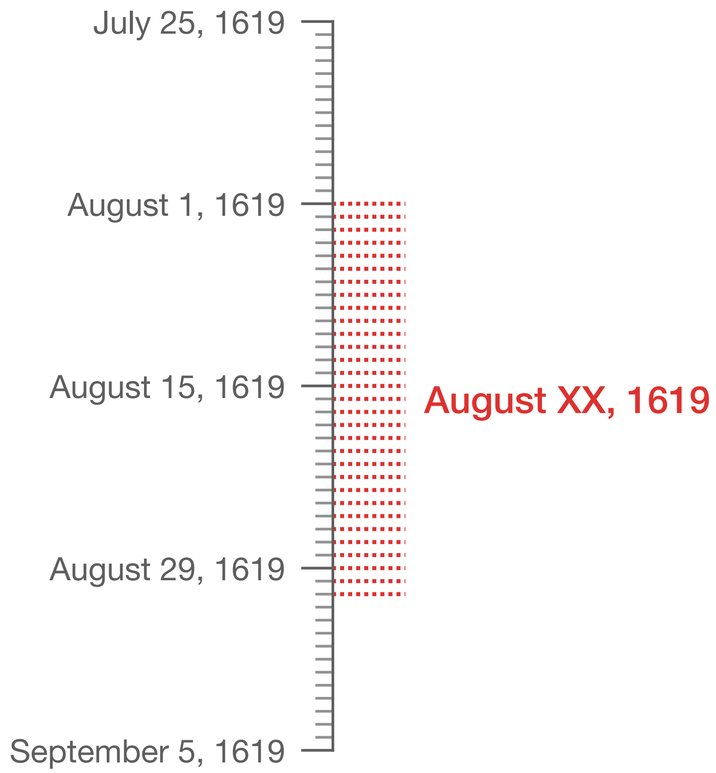


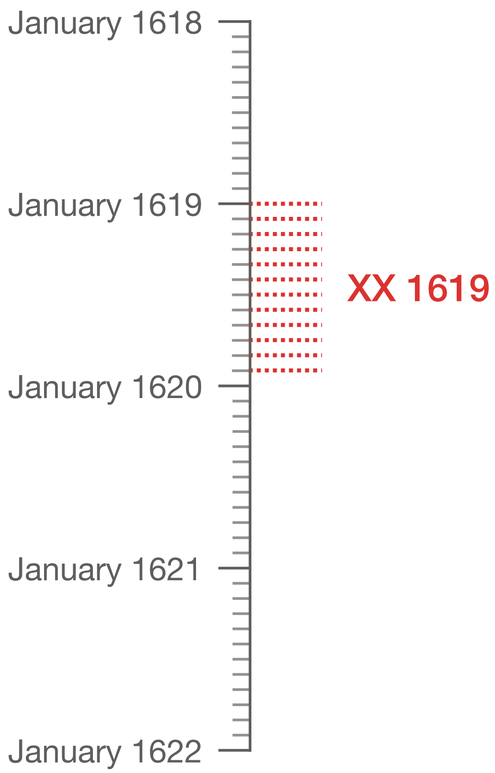
EDTF Level 1

Partially specified dates

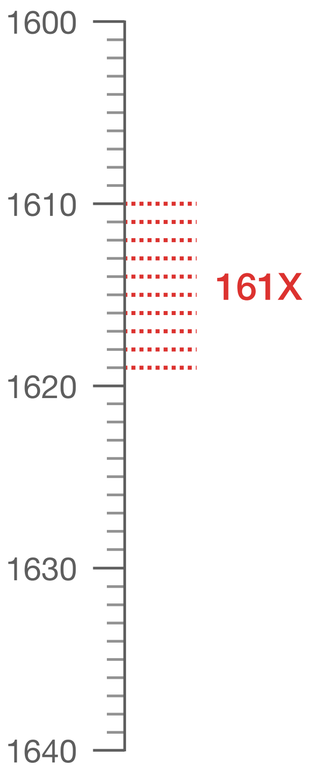
EDTF Level 1



Day precision

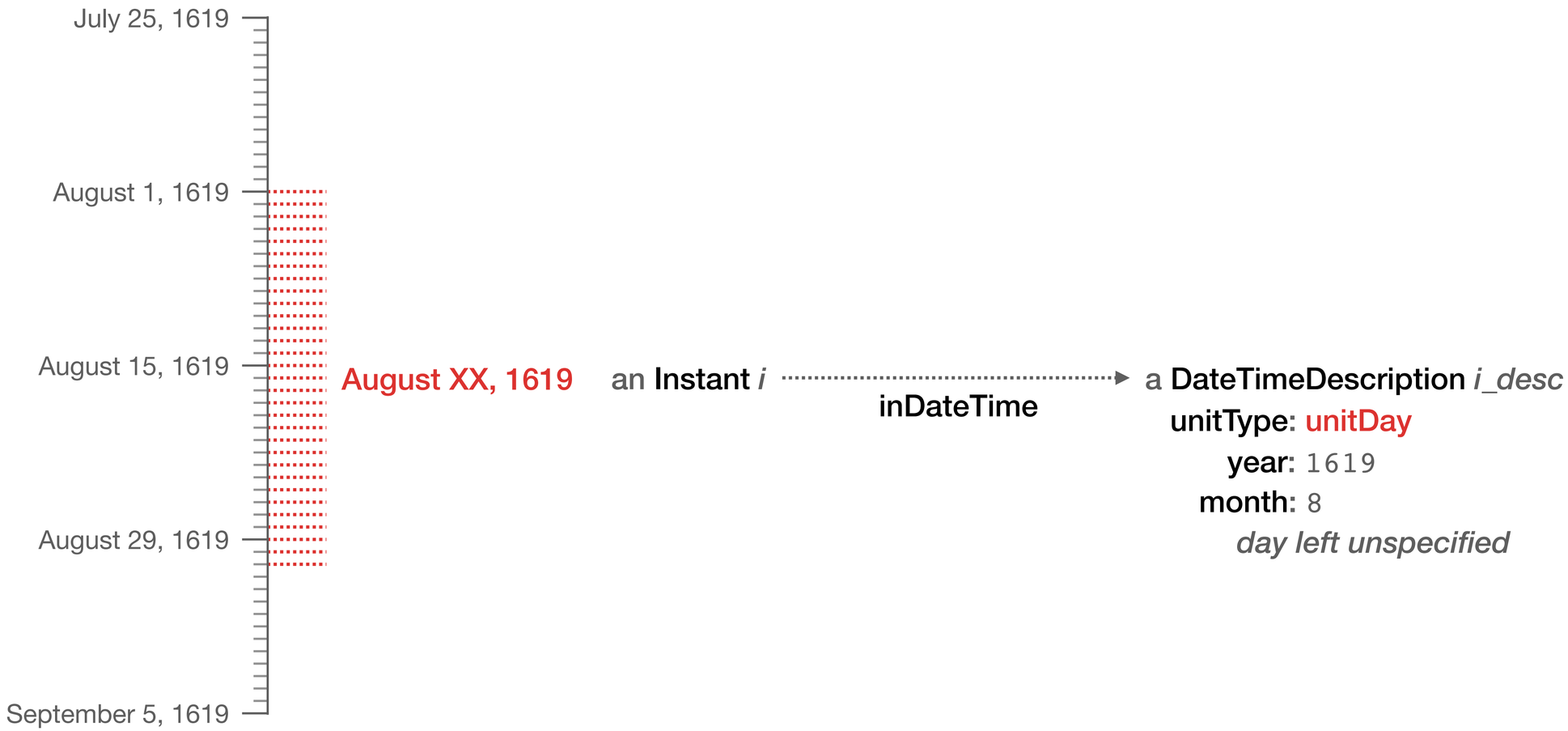


Month precision



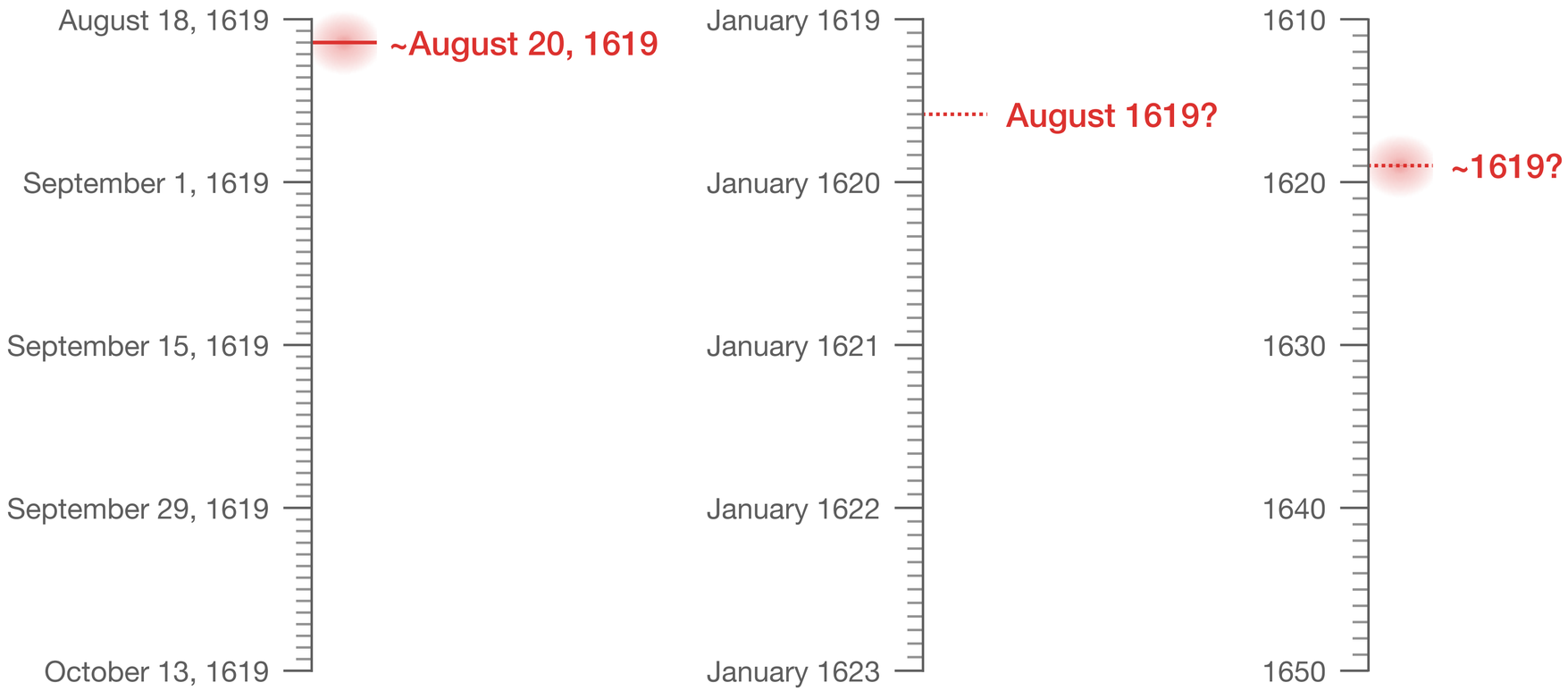
Year precision

Partially specified dates in OWL-Time



Qualified dates

EDTF Level 1

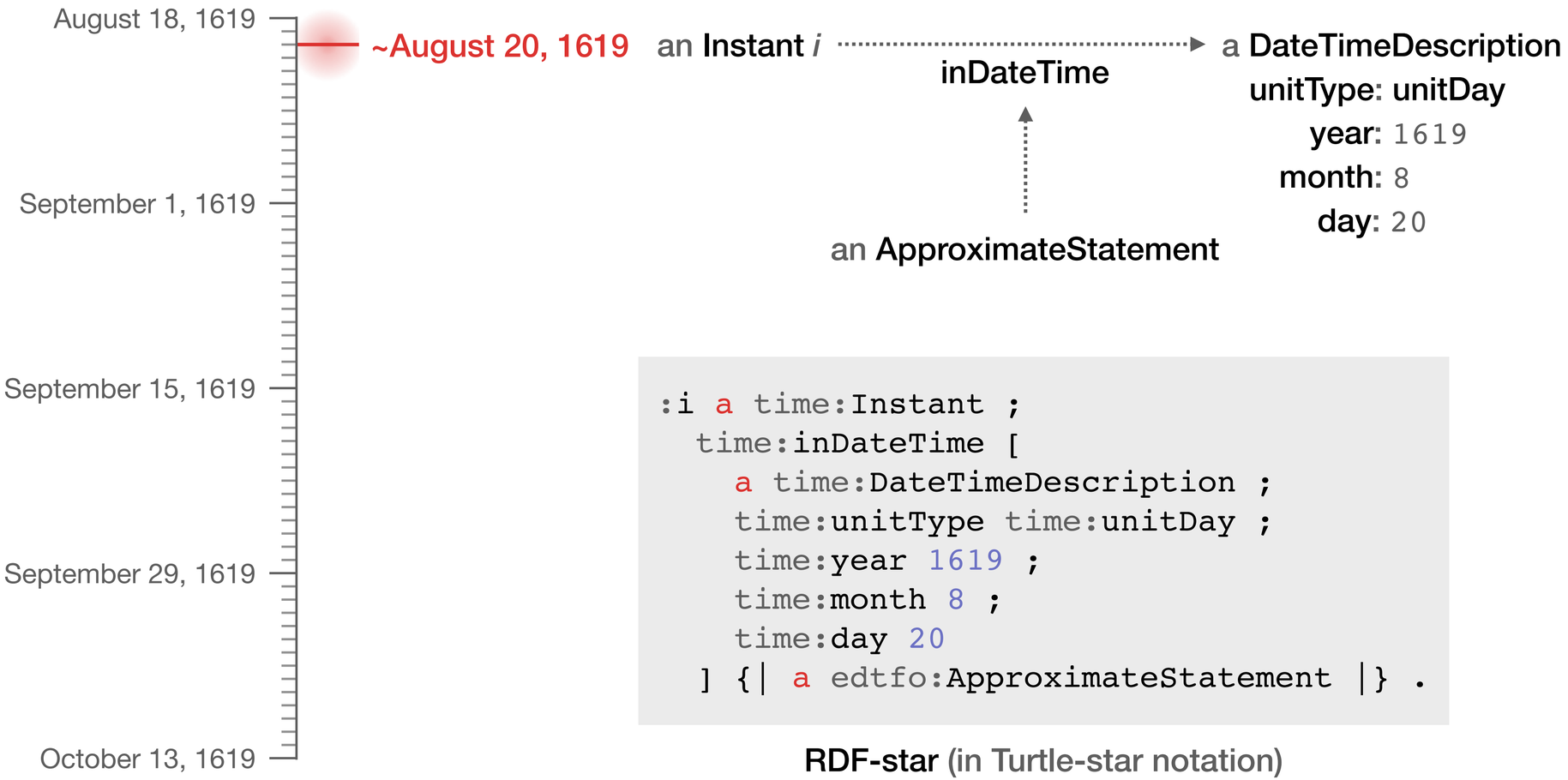


Day precision
Approximate

Month precision
Uncertain

Year precision
Approximate & uncertain

Qualified dates in OWL-Time

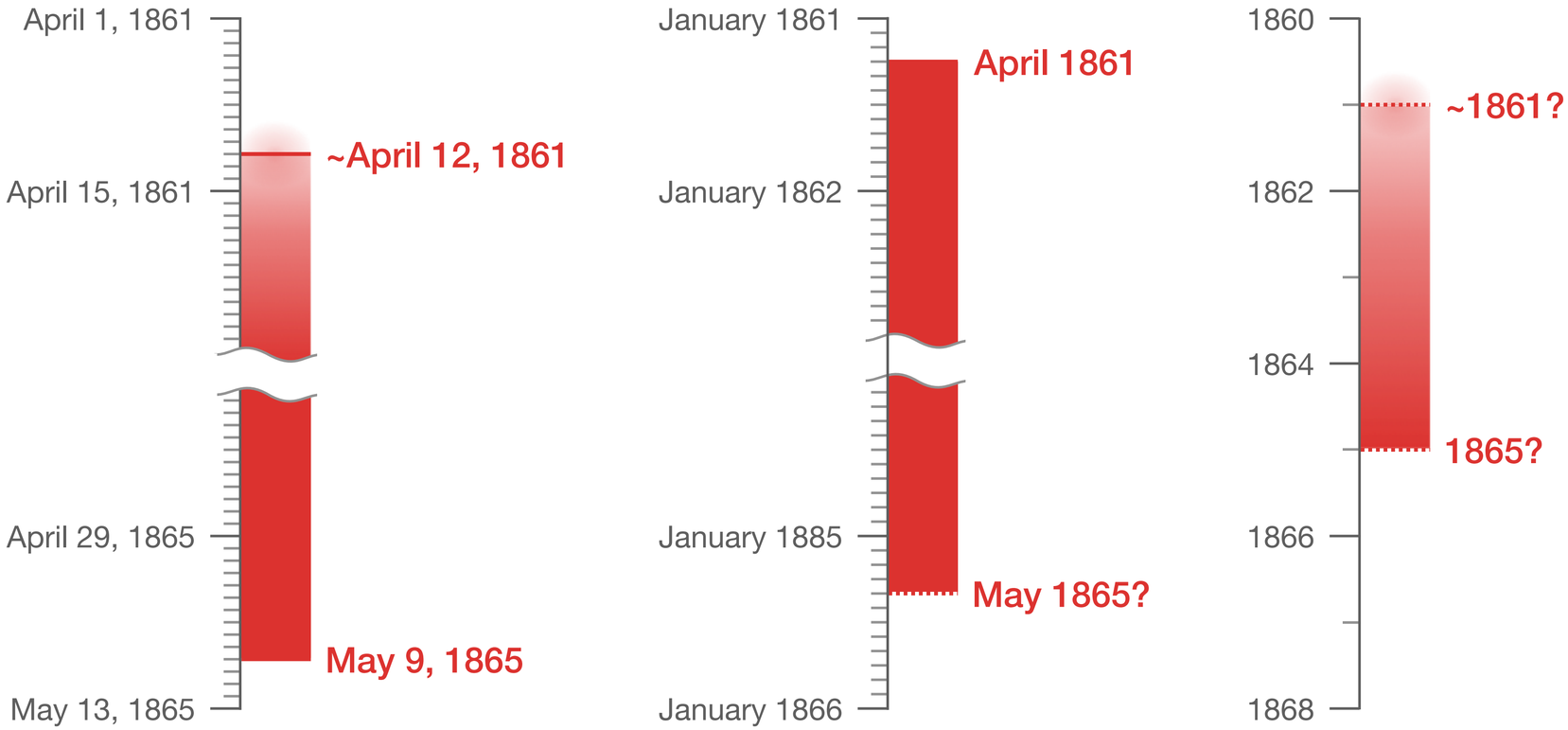



```
:i a time:Instant ;
  time:inDateTime [
    a time:DateTimeDescription ;
    time:unitType time:unitDay ;
    time:year 1619 ;
    time:month 8 ;
    time:day 20
  ] {| a edtfo:ApproximateStatement |} .
```

RDF-star (in Turtle-star notation)

Qualified intervals

EDTF Level 1



Day precision

Qualified start

Month precision

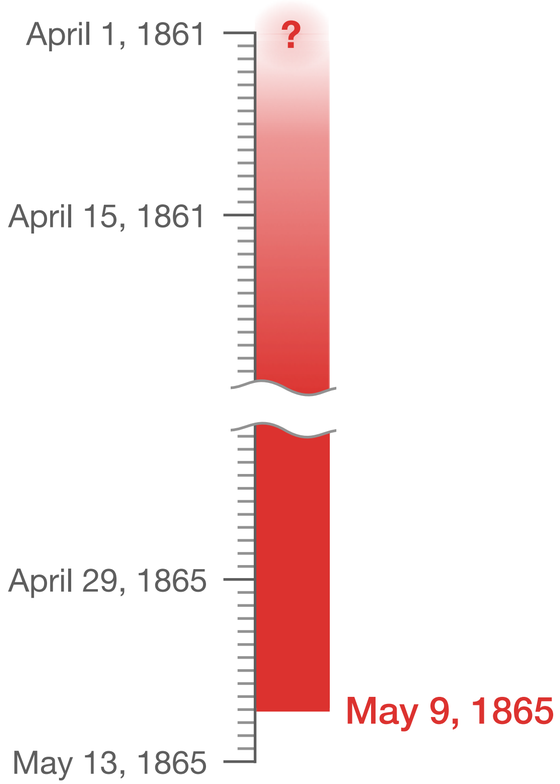
Qualified end

Year precision

Qualified start & end

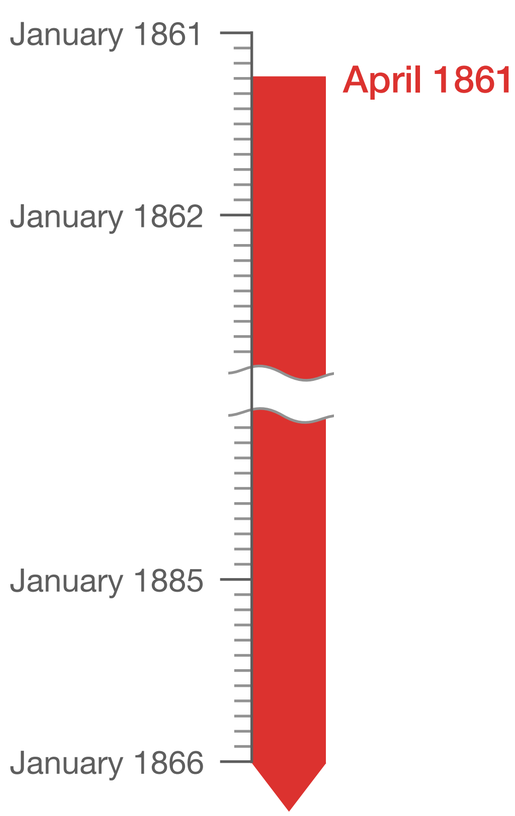
Partially specified intervals

EDTF Level 1



Day precision

Unknown start



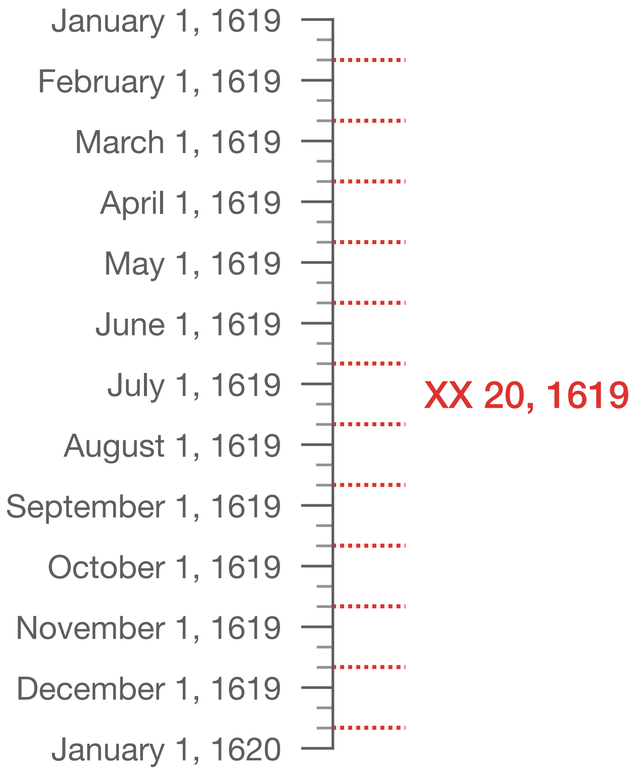
Month precision

Open end

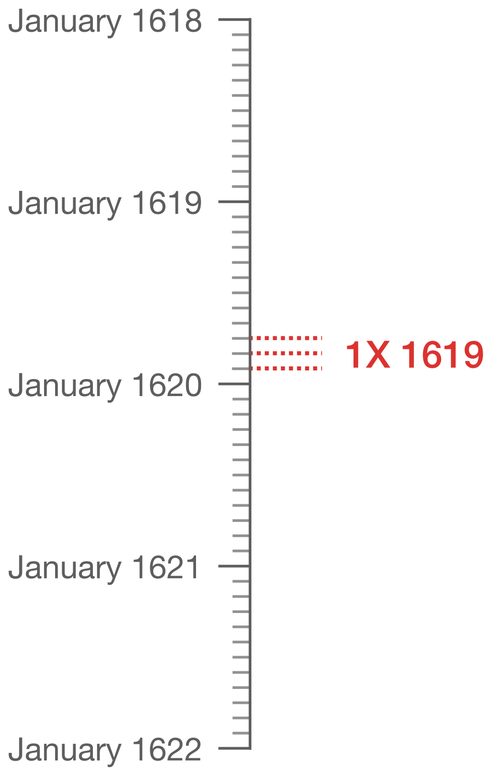
EDTF Level 2

Partially specified dates

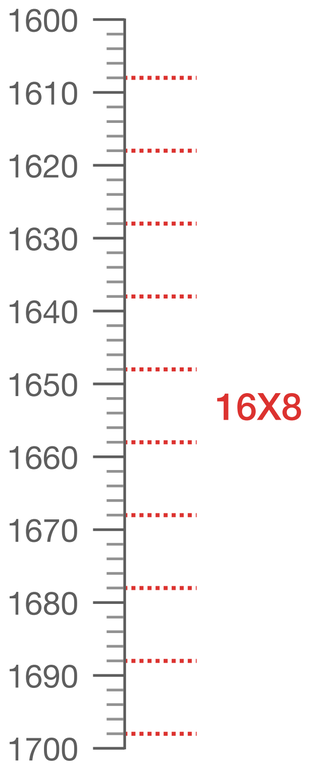
EDTF Level 2



Day precision



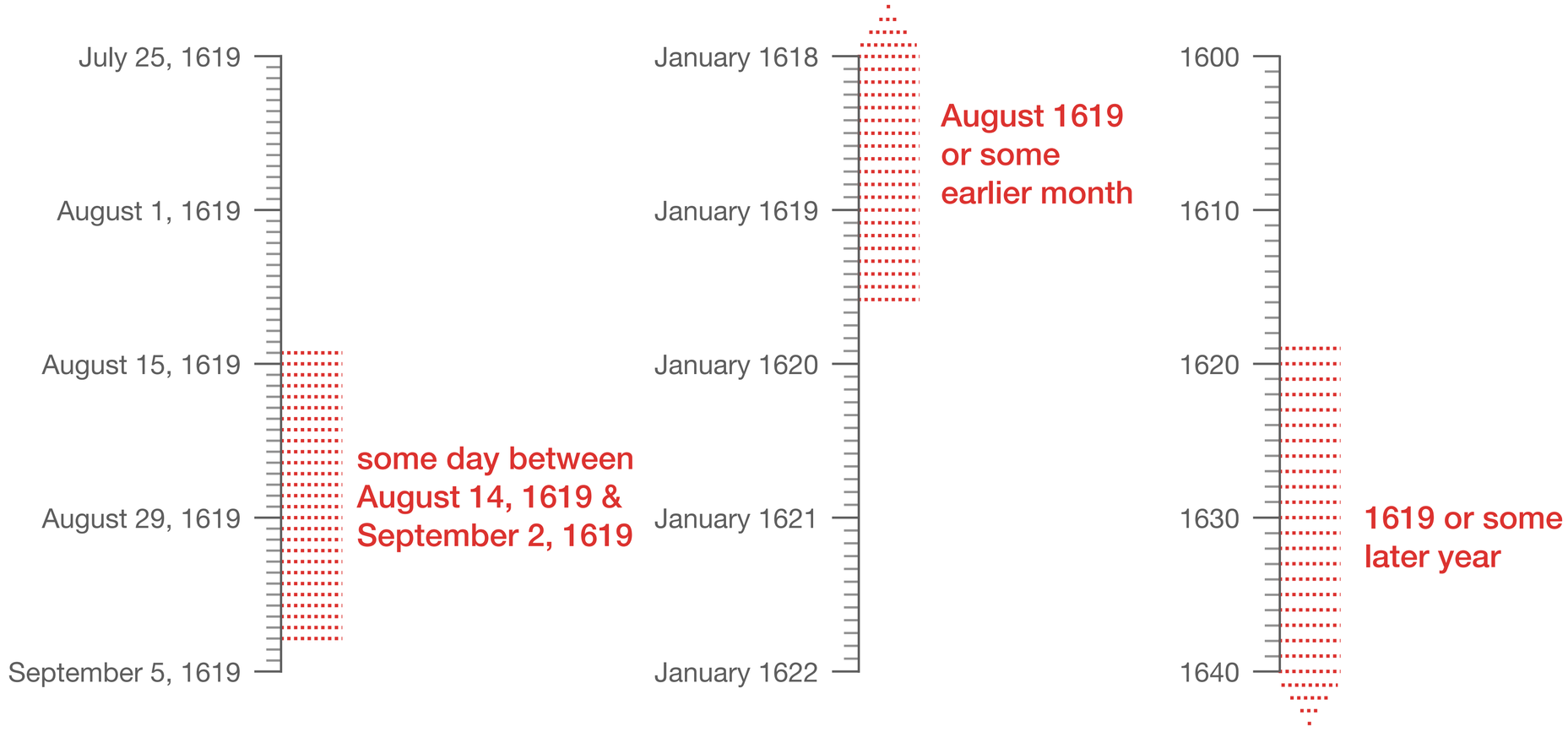
Month precision



Year precision

Ranges of possible dates

EDTF Level 2

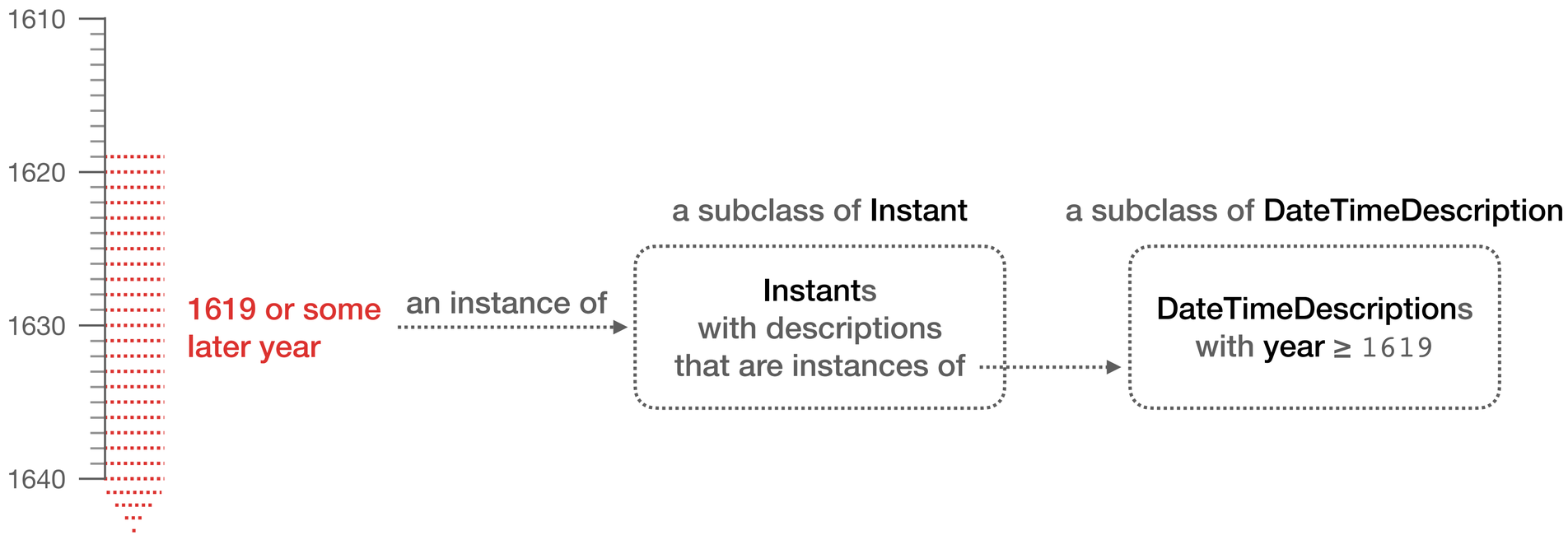


Day precision

Month precision

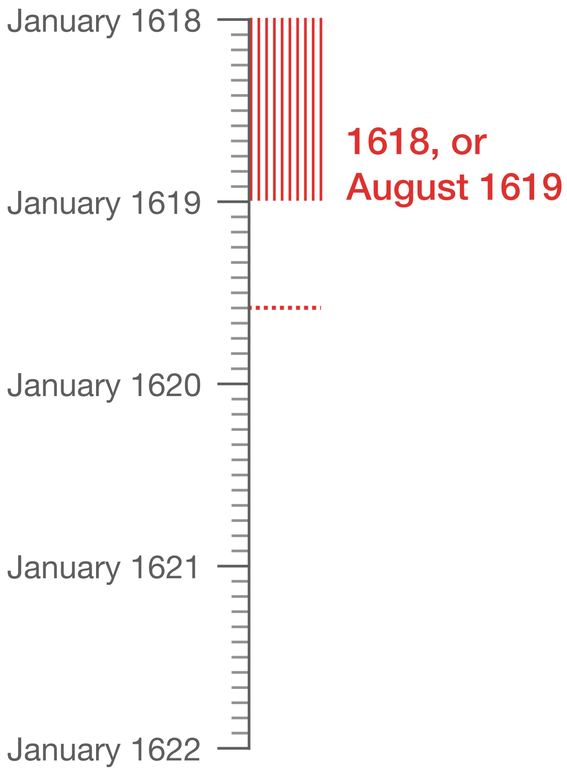
Year precision

Ranges of possible dates in OWL-Time

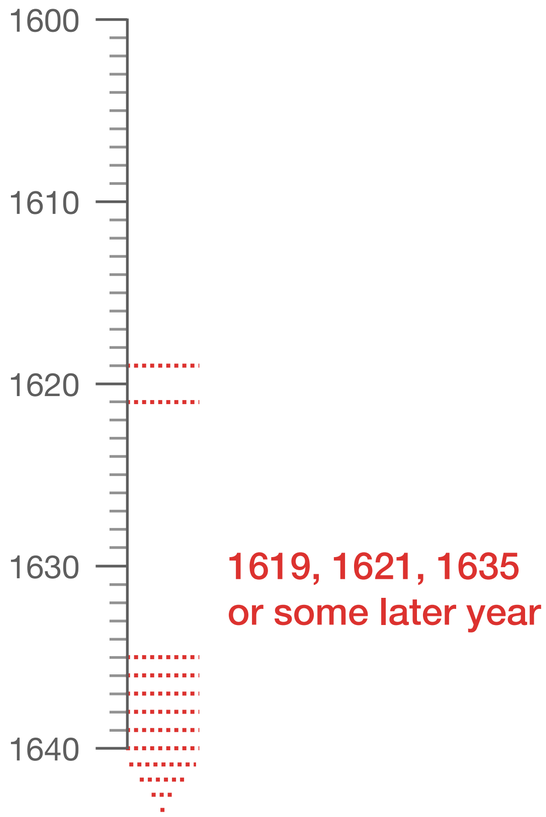


One of a set of dates

EDTF Level 2



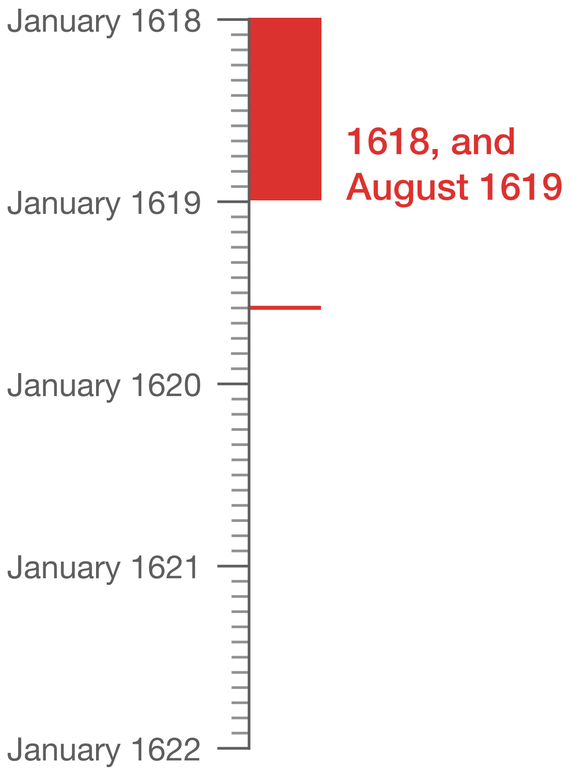
Closed set



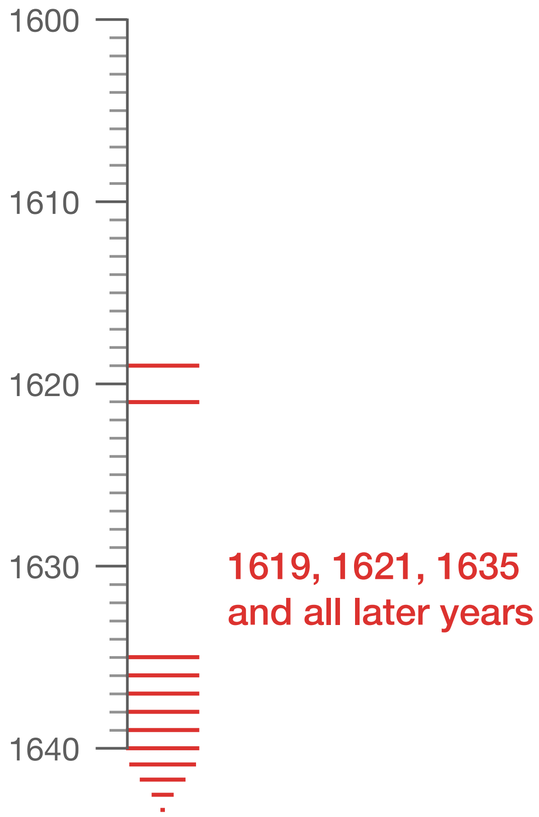
Open set

All of a set of dates

EDTF Level 2

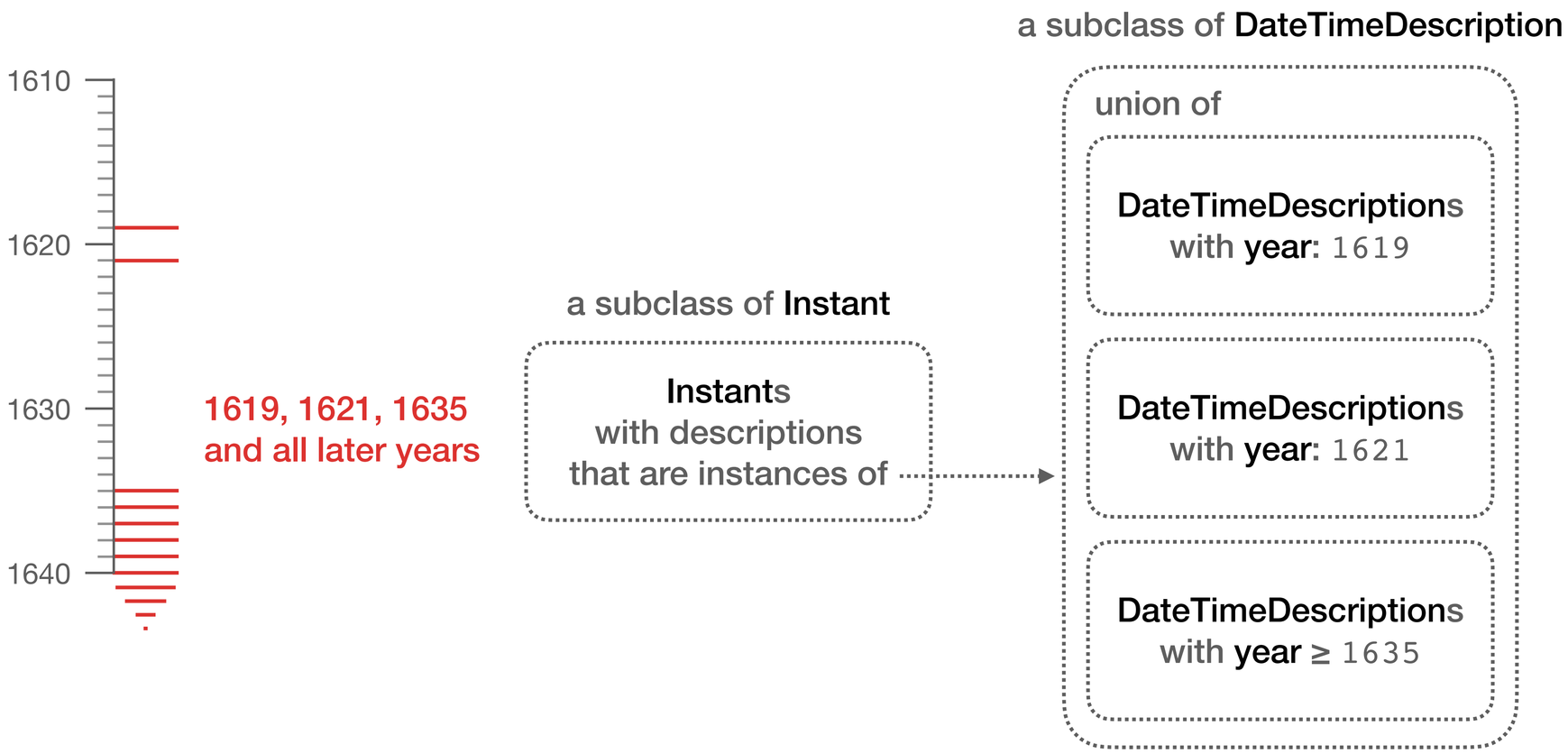


Closed set

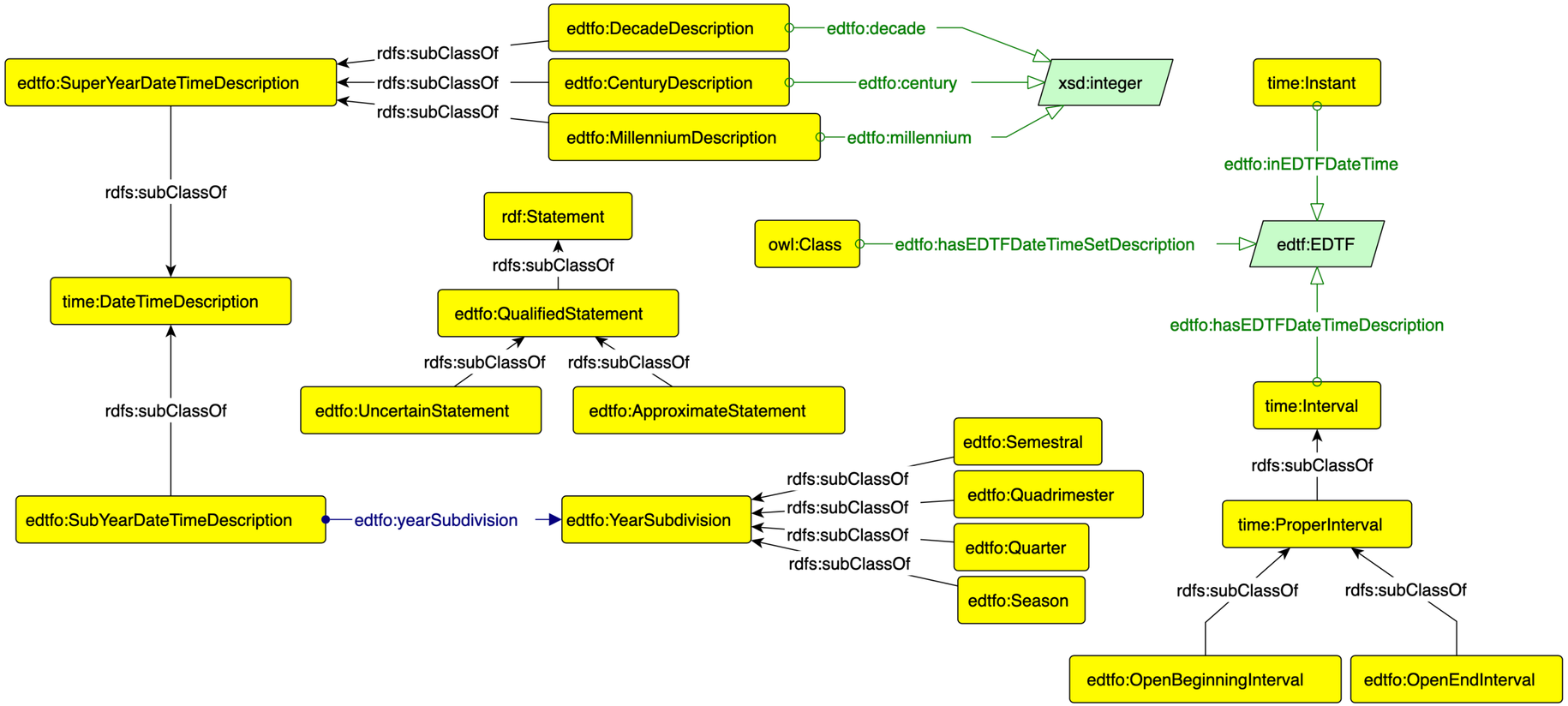


Open set

Sets of possible dates in OWL-Time



Draft EDTF Ontology



https://periodo.github.io/edtf-ontology/

Notation3 rules

for transforming EDTF to OWL-Time

```
{
    re:REDUCED_PRECISION_DATE = ?date

    . ?w edtfo:hasEDTFDateTimeDescription ?edtf
    . ("^(" ?date ")/" ?date "$") string:concatenation ?b_scraper
    . (?edtf ?b_scraper) string:scrape ?b
    . ("^" ?date "/(" ?date ")$") string:concatenation ?e_scraper
    . (?edtf ?e_scraper) string:scrape ?e
} => {
    ?w
      time:hasBeginning [
        edtfo:inEDTFDateTime ?b
      ] ;
      time:hasEnd [
        edtfo:inEDTFDateTime ?e
      ]
    .
} .
```

Temporal reasoning in the browser

Notation3

is a language for reasoning with RDF

- is a superset of Turtle
- has been around for a while (15 years), but interest has recently revived
- specification being revised by the W3C Notation3 Community Group
- Brief introduction:
  https://notation3.org/
- Notation3 by example:
  https://github.com/eyereasoner/Notation3-By-Example
- Draft Community Group Report:
  https://w3c.github.io/N3/reports/20230703/

```
# A triple (same representation as Turtle)
:emma :attended :GrapHNR2023 .
```

Data

```
# A rule with graph patterns
# in the premise and conclusion.
{
  ?x :attended :GrapHNR2023 .
} => {
  ?x a :CoolPerson .
} .
```

Rules

```
# A new triple inferred from everything above
:emma a :CoolPerson .
```

Inferences

```
# A triple (same representation as Turtle)
:emma :hasAge 27 .
```

Data

```
# A rule using a “built-in” N3 predicate.
{
  ?x :age ?age .
  ?age math:greaterThan 17 .
} => {
  ?x a :Adult .
} .
```

Rules

```
# A new triple inferred from everything above
:emma a :Adult .
```

Inferences

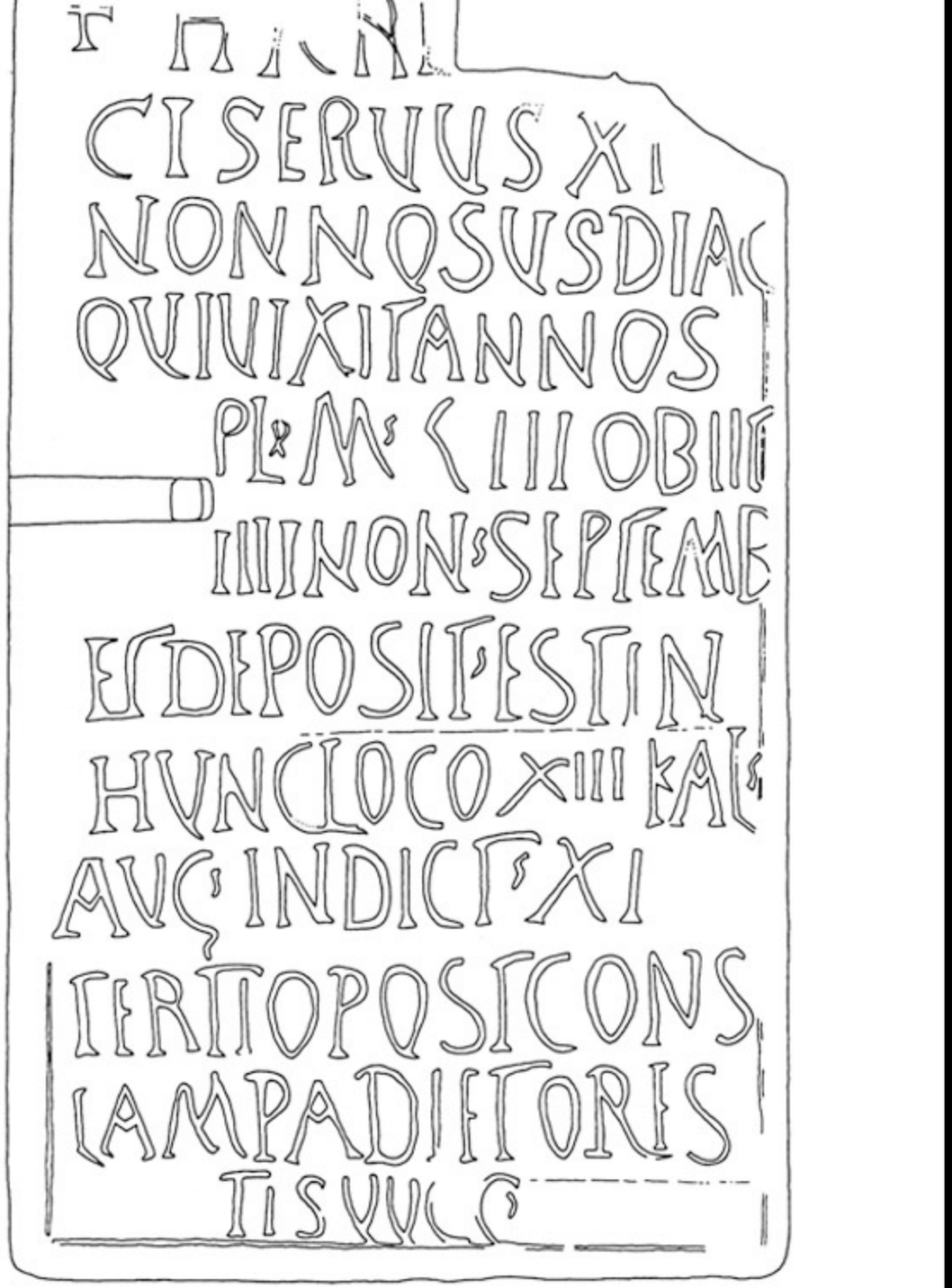
Notation3 reasoners

are what make the inferences happen

- **jen3** based on Apache Jena
  https://github.com/william-vw/jen3
- **eye** based on SWI-Prolog
  https://github.com/eyereasoner/eye
- **eye-js** (eye compiled to be usable in the browser with JavaScript)
  https://github.com/eyereasoner/eye-js

Nonnosus inscription (photo and drawing by F. Glaser)

https://carantana.at/en/exhibition/#iLightbox[image_carousel_3]/1

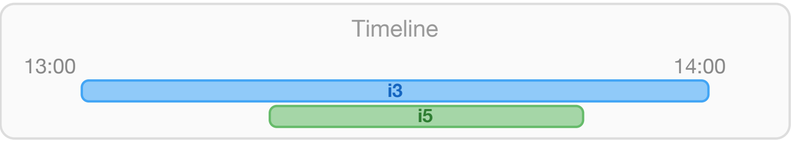


Here rests the servant of Christ, the deacon Nonnosus, who **lived about 103 years**. He **died on September 2nd** and was **buried on July 20th** at this place in the eleventh year of the indiction **three years after the consulship of the most famous men Lampadius and Orestes**.

Demo

Modeling music trade events with CIDOC CRM

Ground Fact Rule Allen Relation Logic Layer Result



1. Facts

interval3
13:00 -- 14:00

interval5
13:15 -- 13:45

Math
13:00<13:15 13:45<14:00

We know when each event happens.
Event 3 runs 1:00-2:00pm. Event 5 runs 1:15-1:45pm.

2. Compare

lemma157
i3 beginsBefore i5 (13:00 < 13:15)

lemma158
i5 endsBefore i3 (13:45 < 14:00)

Compare start and end times.
Event 3 started first. Event 5 ended first.

3. Classify

lemma136
{ ?a beginsAfter ?b . ?a endsBefore ?b } => { (?a ?b) possible (during) }
(i5, i3) logic:possible (allen:during)

Apply the "during" definition.
If one event starts later and ends earlier than another, it happens entirely during the other.

4. Symmetry

lemma116
(i5, i3) logic:possibleWithSymmetry (allen:during)

Check inverse relations too.
Event 3 "contains" Event 5 -- consistent, no conflict.

5. Compose

lemma85
(i5, i3) logic:possibleWithComposition (allen:during)

Check indirect paths via other events.
No chain through other intervals suggests anything different.

6. Intersect

lemma54
1 composition path; intersection = {during}
(i5, i3) logic:strongest (allen:during)

Pick the most specific answer.
All evidence agrees: the only possible relation is "during". This is the strongest result.

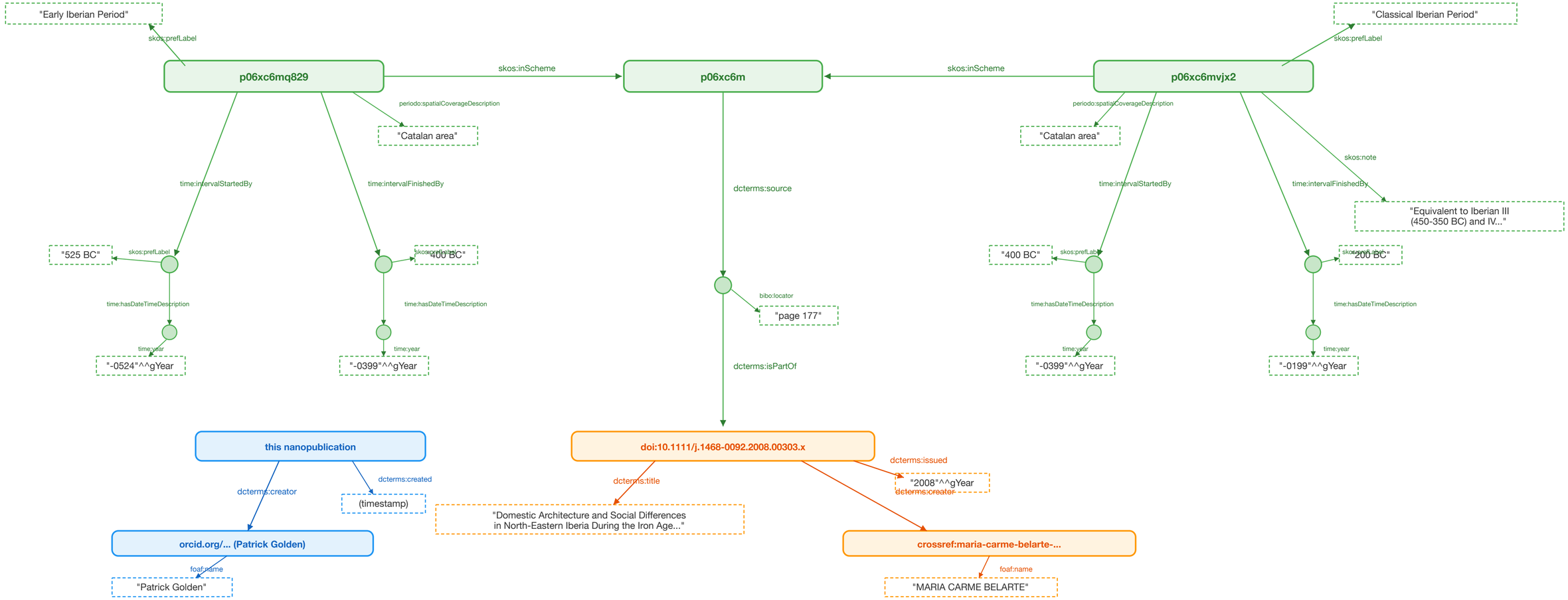
lemma23 -- answer.n3
(interval5, interval3) logic:strongest (allen:during)

Event 5 happens entirely within Event 3.

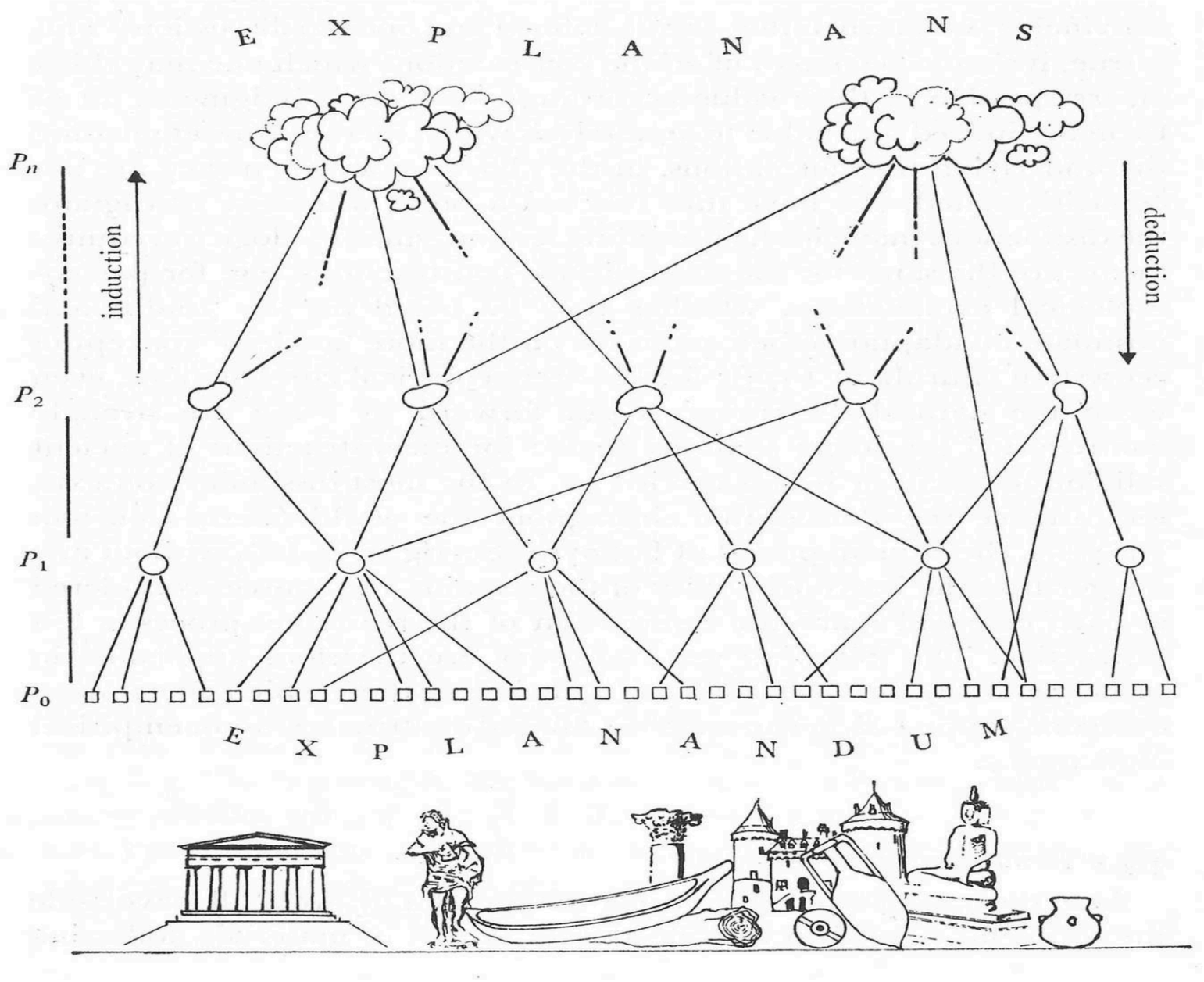
Demo

Looking ahead

Nanopublications



Patrick Golden and Ryan Shaw. Nanopublication beyond the sciences: the PeriodO period gazetteer. *PeerJ Computer Science* 2:e44, 2016. https://doi.org/10.7717/peerj-cs.44



Gardin's logicist model

If a newly available type of analysis changes the dating of a prehistorical homestead—would it not be attractive, to automatically follow the chain of such publications upwards, from the lowest level containing the presumed date, up to and including the authors of a national prehistory, alarming them, that one of their arguments for the state of settlement in part of the country has just crumbled?

Manfred Thaller, “On the extraction and communication of historical knowledge. A pipedream.” https://ivorytower.hypotheses.org/379