

***Sumtiem* soon: temporal reasoning in the browser**

Ryan Shaw, University of North Carolina at Chapel Hill

Sumtiem is a browser-based tool for interactively modeling, visualizing and reasoning about relative, partially known, approximate or uncertain temporal extents. It is intended for use with small-to-medium-sized RDF datasets that include descriptions of relations among time intervals. *Sumtiem* supports modeling time intervals using the Time Ontology in OWL, the CIDOC Conceptual Reference Model, the Extended Date/Time Format (EDTF), or any combination of these. Support for additional temporal modeling vocabularies can be added by writing mapping rules in Notation3, a superset of Turtle that also allows inference rules to be expressed. References to published temporal entities, such as periods in the PeriodO time period gazetteer, are automatically resolved into temporal extents and added to the model. Deductive reasoning about relative time intervals is implemented using Allen's algebra of binary relations. Additional temporal reasoning rules can be added, again using Notation3. *Sumtiem* automatically generates scalable vector graphics (SVG) visualizations of modeled and inferred temporal extents and their relative positions. Data storage, reasoning, and visualization are all executed in the browser. Because no data is uploaded to a server, *Sumtiem* is suitable for use with either private or published linked data.

As an example of the kind of temporal reasoning *Sumtiem* is capable of, consider this inscription on the tombstone of Nonnosus in the altar of the parish church in Molzbichl, Austria:

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.

The assertions made in this inscription can be modeled using the OWL-Time ontology (Figure 1). From this model we can infer temporal boundaries on the possible dates of the birth and death of Nonnosus. To do this we need some inference rules, such as: "If an interval has a known duration in years, and the year of start of the interval is known, then the year of the finish of the interval can be inferred." Figure 2 shows the Notation3 rule for inferring a maximum temporal bound on the date of the birth of Nonnosus, given the duration of his life and the date of his death. Using inference rules like these, the assumptions captured in the initial model can be extended with inferred relations

(Figure 3). Changes to the initial assumptions (for example, the duration of the life of Nonnosus, or the dates of his death or burial) will be automatically reflected in the inferences made.

Development of *Sumtiem* began at the Time in Event Modeling, Periodization and Ordering (TEMPO) hackathon, held 23–25 June 2022 at Universität Wien. It is still under active development, and I am hoping that feedback from attendees of GrapHNR will inform further development. By the time of the conference, the source code will be made available under the MIT license.

FIGURE 1. Initial assumptions modeled using the Time Ontology in OWL.

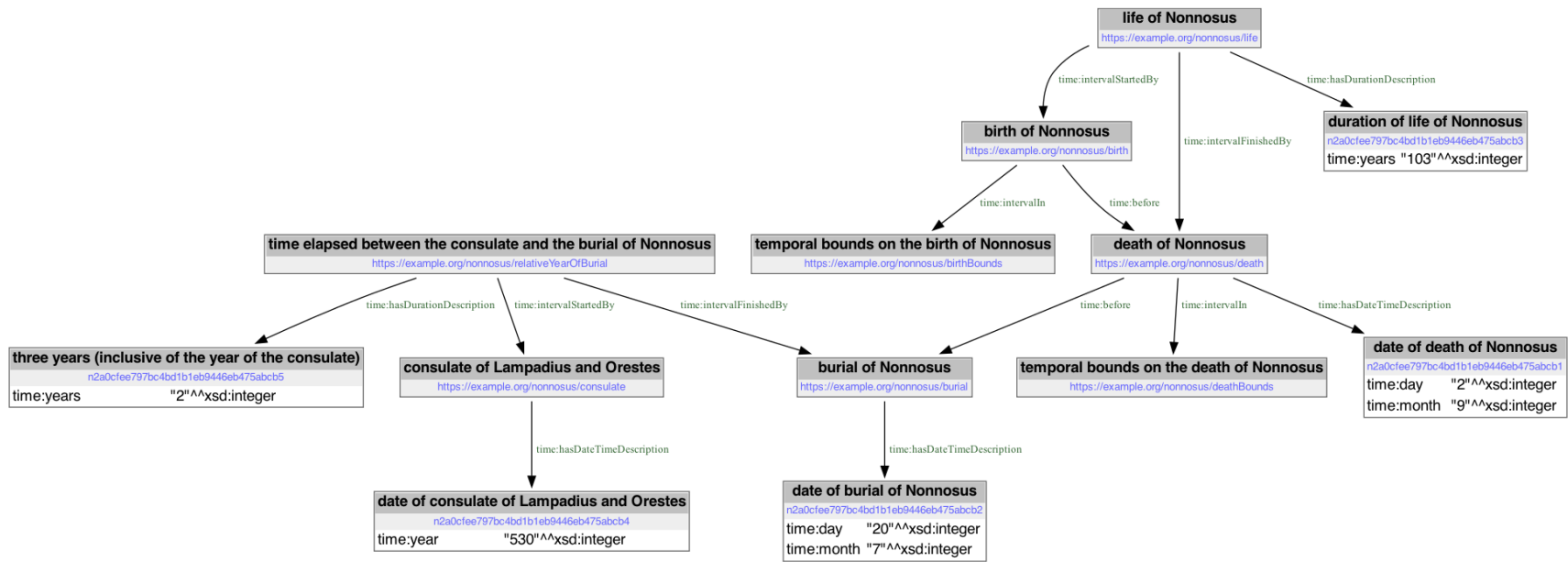


FIGURE 2. An example inference rule written in Notation3.

```
# If a dated interval is inside (bounded by) another interval (the
# bounding interval), and the dated interval must have occurred before
# another interval, the bounding interval also must have occurred
# before that other interval.
{
  ?i1
  time:before ?i2 ;
  time:intervalIn ?i1_bounds .
}=>{
  ?i1_bounds time:before ?i2 .
}.

# If a dated interval occurred before another dated interval, and the
# month of the earlier interval is greater than the month of the later
# interval, then year of the earlier interval is at most one less than
# the year of the later interval.
{
  ?i1 time:before ?i2 .

  ?i1 time:hasEnd [
    time:inDateTime ?i1_e_d
  ].

  ?i1_e_d time:month ?i1_e_month .

  ?i2 time:hasDateTimeDescription [
    time:month ?i2_month ;
    time:year ?i2_year
  ].

  ?i1_e_month math:greaterThan ?i2_month .

  ( ?i2_year 1 ) math:difference ?i1_e_year .
}=>{
  ?i1_e_d time:year ?i1_e_year .
}.
```

FIGURE 3. Model expanded with inferred relations.

