

Time: some models and ontologies

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Time Ontology?

How to define a time ontology that can represent events such as:

- *John was not in the room when I touched the switch to turn on the light* (from [3] p. 837)
- *The teacher arrives in the classroom to give his course*

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W3C Time Ontology

- Ontology of temporal concepts
- Defined by the consortium W3C
- Available in OWL-2 DL
- Developed for describing:
 - the temporal content of Web pages,
 - the temporal properties of Web services,
 - and more generally the temporal properties of any resource with an URI
- More information in [1]

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W3C Time Ontology

Basic class

time:TemporalEntity
with two subclasses
time:Interval
time:Instant

Main properties

time:hasBeginning
time:hasEnd
that link a temporal entity to the instants that define its limits
time:hasTemporalDuration
that links a temporal entity to its extent

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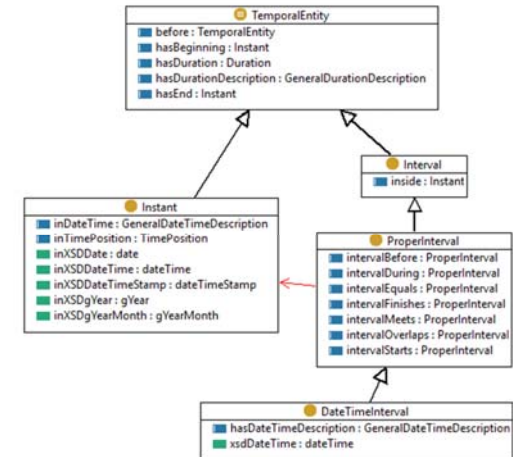
W3C Time Ontology

Intervals

time:Interval
 with one subclass
 time:ProperInterval
 which corresponds to intervals whose beginning and end are different

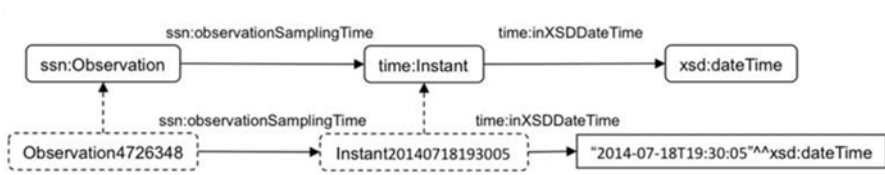
time:ProperInterval
 with one subclass
 time:DateTimeInterval

W3C Time Ontology



W3C Time Ontology

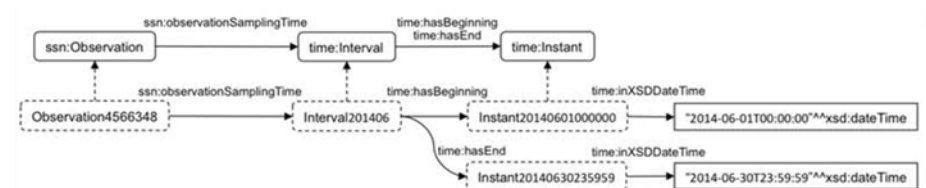
Example: observations represented by time **instants** (from [2])



ssn: refers to Semantic Sensor Ontology
 time: refers to Time Ontology

W3C Time Ontology

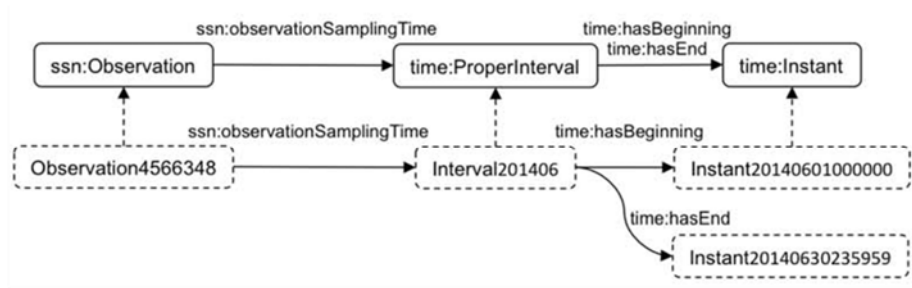
Example: observations represented by time **intervals** (from [2])



ssn: refers to Semantic Sensor Ontology
 time: refers to Time Ontology

W3C Time Ontology

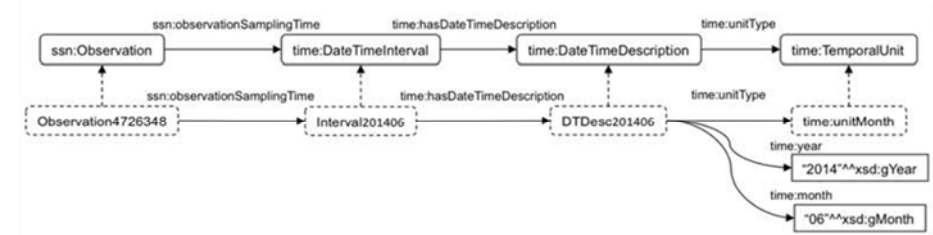
Example: observations represented by **proper** time **intervals** i.e. by intervals whose extremes are different (from [2])



ssn: refers to Semantic Sensor Ontology
time: refers to Time Ontology

W3C Time Ontology

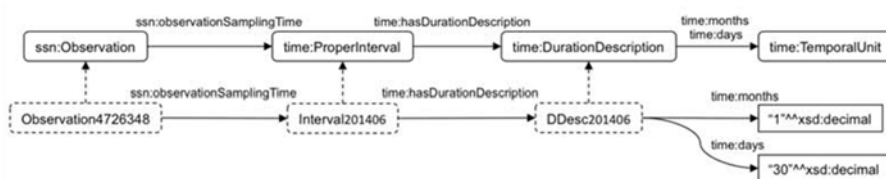
Example: observations represented by **intervals** with a higher level of granularity (from [2])



ssn: refers to Semantic Sensor Ontology
time: refers to Time Ontology

W3C Time Ontology

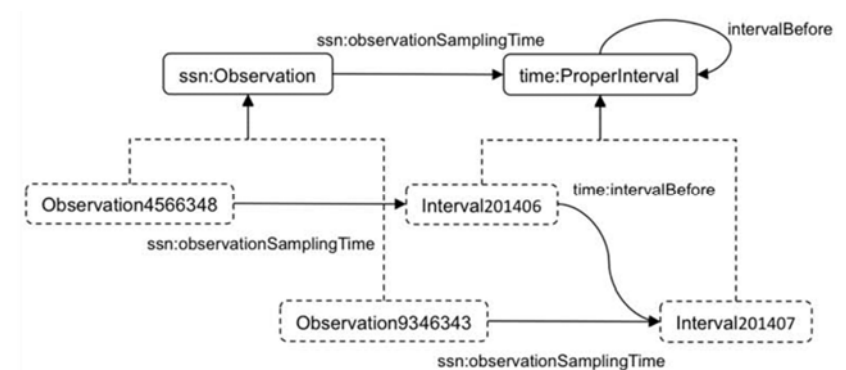
Example: observations represented by time interval **durations** (from [2])



ssn: refers to Semantic Sensor Ontology
time: refers to Time Ontology

W3C Time Ontology

Representation of **relations** between time intervals (from [2])



W3C Time Ontology

Relations between (proper) intervals

As provided by Allen's analysis
Implemented in the time ontology

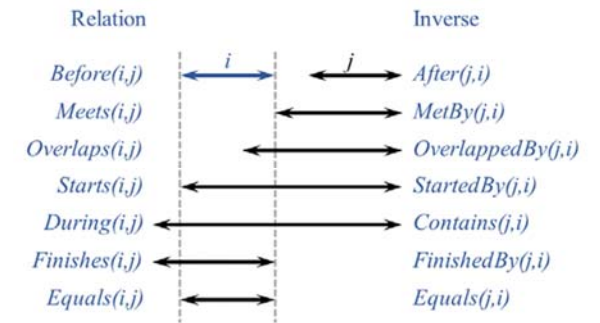
13 Allen's relations (see next slide)

2 additional relations

In (union of **During**, **Starts** and **Finishes**)
Disjoint (union of **Before** and **After**)

Allen's interval algebra

Algebra for temporal reasoning introduced by James F. Allen in 1983 (see [3], [4])



Definition of 13 base possible relations between two intervals

Allen's interval algebra

Different names used for representing the same relations

	From [5]		From [3]	
	precedes	p	before	<
	meets	m	meets	m
	overlaps	o	overlaps	o
	finished-by	F	finished-by	fi
	contains	d	contains	di
	starts	s	starts	s
	equals	e	equals	=
	started-by	s	started-by	si
	during	d	during	d
	finishes	f	finishes	f
	overlapped-by	O	overlapped-by	oi
	met-by	M	met-by	mi
	preceded-by	P	after	>

The W3C Time Ontology

The relations available in the Time Ontology with the 13 relations defined by Allen

Property Name	Domain	Range
before	TemporalEntity	TemporalEntity
after	TemporalEntity	TemporalEntity
hasBeginning	TemporalEntity	Instant
hasEnd	TemporalEntity	Instant
inside	Interval	Instant
intervalEquals	ProperInterval	ProperInterval
intervalBefore	ProperInterval	ProperInterval
intervalMeets	ProperInterval	ProperInterval
intervalOverlaps	ProperInterval	ProperInterval
intervalStarts	ProperInterval	ProperInterval
intervalDuring	ProperInterval	ProperInterval
intervalFinishes	ProperInterval	ProperInterval
intervalAfter	ProperInterval	ProperInterval
intervalMetBy	ProperInterval	ProperInterval
intervalOverlappedBy	ProperInterval	ProperInterval
intervalStartedBy	ProperInterval	ProperInterval
intervalContains	ProperInterval	ProperInterval
intervalFinishedBy	ProperInterval	ProperInterval
years	DurationDescription	xsd:decimal
months	DurationDescription	xsd:decimal
weeks	DurationDescription	xsd:decimal
days	DurationDescription	xsd:decimal
hours	DurationDescription	xsd:decimal
minutes	DurationDescription	xsd:decimal
seconds	DurationDescription	xsd:decimal
hasDurationDescription	TemporalEntity	DurationDescription
unitType	Date TimeDescription	TemporalUnit
year	Date TimeDescription	xsd:gYear
month	Date TimeDescription	xsd:gMonth
week	Date TimeDescription	xsd:nonNegativeInteger
day	Date TimeDescription	xsd:gDay
dayOfWeek	Date TimeDescription	DayOfWeek
dayOfYear	Date TimeDescription	xsd:nonNegativeInteger
hour	Date TimeDescription	xsd:nonNegativeInteger
minute	Date TimeDescription	xsd:nonNegativeInteger
second	Date TimeDescription	xsd:decimal
timeZone	Date TimeDescription	zont:TimeZone
inDateTime	Instant	Date TimeDescription
inXSDDate	Instant	xsd:date
hasDateTimeDescription	Date TimeInterval	Date TimeDescription
xsdDate	Date TimeInterval	xsd:date

From [1]

Allen's interval algebra

The basic relations and their **converse**

Relation	(p)	(P)	Converse
precedes	(p)	(P)	preceded by
meets	(m)	(M)	met by
overlaps	(o)	(O)	overlapped by
finished by	(F)	(f)	finishes
contains	(D)	(d)	during
starts	(s)	(S)	started by
	equals (e)		

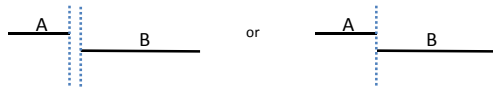
From [5]

Example: *the teacher arrives in the classroom to give his course*

Let *A* be the time the teacher arrives in the classroom (including preparing the teaching material)

and *B* be the time the teachers gives his course

then we can say that: *A* (pm) *B*



Allen's interval algebra

The basic relations and their **composition**

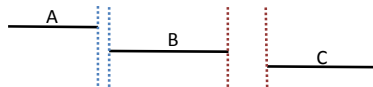
.	p	m	o	F	D	s	e	S	d	f	O	M	P
p	(p)	(p)	(p)	(p)	(p)	(p)	(p)	(p)	(pmsod)	(pmsod)	(pmsod)	(pmsod)	full
m	(p)	(p)	(p)	(p)	(p)	(m)	(m)	(m)	(osd)	(osd)	(osd)	(Fef)	(DSOMP)
o	(p)	(p)	(pmo)	(pmo)	(pmoFD)	(o)	(o)	(oFD)	(osd)	(osd)	concur	(DSO)	(DSOMP)
F	(p)	(m)	(o)	(F)	(D)	(o)	(F)	(D)	(osd)	(Fef)	(DSO)	(DSO)	(DSOMP)
D	(pmoFD)	(oFD)	(oFD)	(D)	(D)	(oFD)	(D)	(D)	concur	(DSO)	(DSO)	(DSO)	(DSOMP)
s	(p)	(p)	(pmo)	(pmo)	(pmoFD)	(s)	(s)	(seS)	(d)	(d)	(dfO)	(M)	(P)
e	(p)	(m)	(o)	(F)	(D)	(s)	(e)	(S)	(d)	(f)	(O)	(M)	(P)
S	(pmoFD)	(oFD)	(oFD)	(D)	(D)	(seS)	(S)	(S)	(dfO)	(O)	(O)	(M)	(P)
d	(p)	(p)	(pmsod)	(pmsod)	full	(d)	(d)	(dfOMP)	(d)	(d)	(dfOMP)	(P)	(P)
f	(p)	(m)	(osd)	(Fef)	(DSOMP)	(d)	(f)	(OMP)	(d)	(f)	(OMP)	(P)	(P)
O	(pmoFD)	(oFD)	concur	(DSO)	(DSOMP)	(dfO)	(O)	(OMP)	(dfO)	(O)	(OMP)	(P)	(P)
M	(pmoFD)	(seS)	(dfO)	(M)	(P)	(dfO)	(M)	(P)	(dfO)	(M)	(P)	(P)	(P)
P	full	(dfOMP)	(dfOMP)	(P)	(P)	(dfOMP)	(P)	(P)	(dfOMP)	(P)	(P)	(P)	(P)

From [5]

Composition of relations: examples

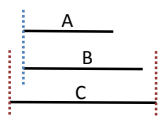
If *A* (p) *B* and *B* (p) *C* then *A* (p) *C*

If *A* precedes *B* and *B* precedes *C* then *A* precedes *C*



If *A* (s) *B* and *B* (d) *C* then *A* (d) *C*

If *A* starts *B* and *B* during *C* then *A* during *C*

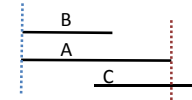


Composition of relations: examples

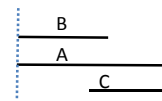
If *A* (S) *B* and *B* (o) *C* then *A* (oFD) *C*

If *A* started by *B* and *B* overlaps *C* then

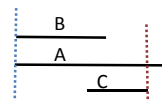
- either *A* overlaps *C* *A* (o) *C*



- or *A* finished by *C* *A* (F) *C*



- or *A* contains *C* *A* (D) *C*



Exercise

Using the W3C time ontology define the following proper intervals :

- *Arrive*
- *Arrive_on_time* (for a course and a person)
- *Follow_a_course*
- *Check_email*
- *Check_email_at_right_time* (not during a course)

References

- [1] W3C Time ontology (in OWL)
<https://www.w3.org/TR/owl-time/>
- [2] Guidelines for using the W3C Time Ontology
<http://knowledgecraver.blogspot.ch/2014/07/guidelines-for-using-w3c-time-ontology.html>
- [3] Allen J. F. Allen *Maintaining knowledge about temporal intervals*. In: *Communications of the ACM*, 26 November 1983, ACM Press, pp. 832–843, ISSN 0001-0782
- [4] Allen's interval algebra on Wikipedia
http://en.wikipedia.org/wiki/Allen%27s_interval_algebra
- [5] Allen's Interval Algebra
<http://www.ics.uci.edu/~alspaugh/cls/shr/allen.html>

Allen's interval algebra

With the vocabulary of Time Ontology

Definition of 13 base possible relations between two intervals

Relation	Illustration	Interpretation
$X < Y$	X intervalBefore Y 	X takes place before Y
$Y > X$	Y intervalAfter X 	
$X m Y$	X intervalMeets Y 	X meets Y (<i>i</i> stands for <i>inverse</i>)
$Y mi X$	Y intervalMetBy X 	
$X o Y$	X intervalOverlaps Y 	X overlaps with Y
$Y oi X$	Y intervalOverlappedBy X 	
$X s Y$	X intervalStarts Y 	X starts Y
$Y si X$	Y intervalStartedBy X 	
$X d Y$	X intervalDuring Y 	X during Y
$Y di X$	Y intervalContains X 	
$X f Y$	X intervalFinishes Y 	X finishes Y
$Y fi X$	Y intervalFinishedBy X 	
$X = Y$	X intervalEquals Y Y intervalEquals X 	X is equal to Y