

# STORING IMPERFECT TEMPORAL INFORMATION ABOUT CULTURAL HERITAGE IN A RELATIONAL DATABASE

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Flanders Heritage Agency

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# SUMMARY

## INTRODUCTION

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## PERIOD BASED SYSTEMS

Archaeological Inventory

Architectural Inventory

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Architectural Inventory

## DATE BASED SYSTEMS

Historic People

Representing imperfect time

Heritage Events

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## WHERE ARE WE HEADED?

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- Archaeological Inventory
- Architectural Inventory

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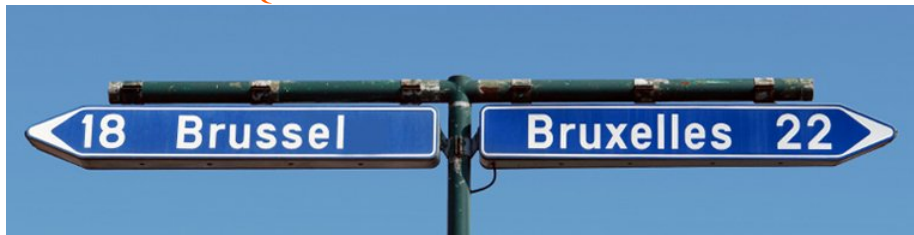
- Historic People
- Representing imperfect time
- Heritage Events

## WHERE ARE WE HEADED?

## CONCLUSION

# WHERE ARE WE?

BELGIUM - BELGIQUE - BELGIË



# BELGIUM - BELGIQUE - BELGIË





# WHO ARE WE?

## FLANDERS HERITAGE AGENCY

An agency of the Flemish Government dealing with inventories, protection, management, research and dissemination of Immovable Heritage (Archaeology, Monuments, Landscapes, Maritime Heritage)

- ▶ `https://www.onroerendergoed.be`
- ▶ Focus shift from research to heritage management
- ▶ Datasets about the whole of Flanders, focus on the big picture
- ▶ Data collection since 1970
- ▶ Digital data since 1990

# WHO AM I?

- ▶ Archaeologist (Pre- and Proto History)
- ▶ Working with digital inventories since 2001
- ▶ IT
- ▶ Masters thesis on handling imperfect temporal information in a relational database (PostgreSQL)
- ▶ Responsible for heritage inventory management system
- ▶ `https://inventaris.onroenderfgoed.be`

# THE QUESTIONS

- ▶ Who?
- ▶ What?
- ▶ How?
- ▶ Why?
- ▶ Where?
- ▶ *When?*

# THE QUESTIONS

- ▶ Who?
- ▶ What?
- ▶ How?
- ▶ Why?
- ▶ Where?
- ▶ *When?*

## WHEN

Temporal information is often imperfect.

- ▶ Nobody knows (uncertainty)
- ▶ Somebody knows, but we don't (uncertainty)
- ▶ Somebody knows, but they only told us some of it (granularity)
- ▶ Nobody can know (subjectivity)

# OUR GOALS

## DATING

We need to be able to date heritage to certain moments in time.

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Our main inventory systems had more than 1.300.000 visits last year. It's used daily for heritage management, spatial planning, ... Querying and searching needs to be fast.

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### USER FRIENDLY

Our data entry users range from trained heritage professionals to volunteers and support staff. Data entry needs to be simple.





# OUR TECHNOLOGY

## OPEN SOURCE

We try to implement as much software as we can using (F)OSS software.  
Where possible we try to contribute.

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## POSTGRESQL

Our RDBMS of choice.

- ▶ Open source
- ▶ No licensing costs
- ▶ Robust
- ▶ Performant
- ▶ Extensible
- ▶ PostGIS



onroerend  
erfgoed

Ga naar een gemeente, straat of adres:

Geef een gemeente, straat of adres op.



Lagen kiezen



#### BASISLAGEN

- Open Streetmap
- Orthofoto's 2012
- GRB - Basiskaart
- GRB - Basiskaart (kleur)

#### OVERLAYS

-  Centrale Archeologische Inventaris

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# CAI

- ▶ An inventory of some 30.000 archaeological findspots in Flanders
- ▶ Mainly used in spatial planning
- ▶ Strong geospatial component
- ▶ Offline editing since 2000 (MS Access)
- ▶ Online reading since 2004 (Mysql)
- ▶ Data: Prehistoric to World War I and II

# CAI - TIME

## COARSE PERIODS OF TIME

- ▶ Roman > Undetermined > Undetermined
- ▶ Iron Age > Undetermined > Undetermined
- ▶ Medieval > Early Medieval > Merovingian
- ▶ Newest Age > 20th century > Undetermined

## GRANULARITY

No need for very fine dates. Granularity does not even approach years.

## INDEXING

*When?* used as an indexing mechanism. There is no real dating going on here.

# CAI - SEARCH FORM

<b>Datering</b>	
<b>Ruwe datering</b>	Steentijd ▼
<b>Verfijning1</b>	Neolithicum ▼
<b>Verfijning2</b>	Finaal-Neolithicum ▼

# CAI - SEARCH RESULT

Zoekresultaten					
Locatie	Naam	Nk	Provincie	Gemeente	Deelgemeente
977	Aalter Brug Noord 04	Tot op 15m	Oost-Vlaanderen	Aalter	Aalter
30262	Voordestraat (Aquafin Zone 1)	Tot op 15m	Oost-Vlaanderen	Nevele	Merendree
30350	Boudelo-Abdij	Tot op 15m	Oost-Vlaanderen	Stekene	Stekene
40118	Flanders Expo Zone 1	Tot op 15m	Oost-Vlaanderen	Gent	Sint-Denijs-Westrem
150881	Moerasstraat (KH07-MS)	Tot op 15m	Oost-Vlaanderen	Kruishoutem	Kruishoutem
151116	Flanders Expo Zone 5 / ECPD	Tot op 15m	Oost-Vlaanderen	Gent	Sint-Denijs-Westrem
163457	Flanders Expo Zone 2 Veld 12W	Tot op 15m	Oost-Vlaanderen	Gent	Sint-Denijs-Westrem
31665	Meerkens	Tot op 150m	Oost-Vlaanderen	Wetteren	Wetteren

Vorige | Pagina 1 van 1 / Locaties 0 tot 8 van 8 | Volgende  
Eerste | 1 | Laatste

# CAI - DETAIL

## Locatie 40118

<b>Nauwkeurigheid</b>	Tot op 15m
<b>Provincie</b>	Oost-Vlaanderen
<b>Gemeente</b>	Gent
<b>Deelgemeente</b>	Sint-Denijs-Westrem
<b>Naam</b>	Flanders Expo Zone 1
<b>Toponiem</b>	Vliegveld
<b>Beschrijving</b>	

## Structuur 31249

<b>Datering</b>	<b>Onbepaald</b>
<b>Verfijning1</b>	Onbepaald
<b>Verfijning2</b>	Onbepaald
<b>Opmerkingen</b>	

<b>Datering</b>	<b>Middeleeuwen</b>
<b>Verfijning1</b>	Late Middeleeuwen
<b>Verfijning2</b>	Onbepaald
<b>Opmerkingen</b>	

<b>Datering</b>	<b>Metaaltijden</b>
<b>Verfijning1</b>	Ijzertijd
<b>Verfijning2</b>	Late Ijzertijd (Westen)
<b>Opmerkingen</b>	vermoedelijk 4de tot 3de eeuw v.Chr.

## Gegevensinvoer

Datum	Invoerder	Instelling	Aard Invoer
13-11-2008	Lien Lombaert	RUG	Eerste invoer
29-10-2010	Sophie Mortier	VIOE	Hiaten: Toevoegen bron
29-10-2010	Sophie Mortier	VIOE	Hiaten: Aanvullen gegevens record ahv bron
06-01-2011	Sophie Mortier	VIOE	Hiaten: Toevoegen bron
24-03-2011	Sophie Mortier	VIOE	Hiaten: Toevoegen bronnen
24-03-2011	Sophie Mortier	VIOE	Hiaten: Aanvullen gegevens record ahv bron
06-04-2011	Sophie Mortier	VIOE	Hiaten: Toevoegen bron

## Grondsporen

<b>Interpretatie</b>	<b>Bewoning</b>
<b>Klasse</b>	Alleenstaand
<b>Subklasse</b>	Onbepaald
<b>Opmerkingen</b>	grijze laag met stukjes prehistorisch aardewerk, mogelijk vulling van een oude depressie.

<b>Interpretatie</b>	<b>Infrastructuur</b>
<b>Klasse</b>	Lijnelementen
<b>Subklasse</b>	Onbepaald
<b>Opmerkingen</b>	Een aantal greppels en een beperkt aantal kuilen (aardewerk in de vulling wijst op 15de-16de eeuw)

<b>Interpretatie</b>	<b>Bewoning</b>
<b>Klasse</b>	Gegroepeerd
<b>Subklasse</b>	Nederzetting
<b>Opmerkingen</b>	5 clusters van sporen (vnl. paalsporen en kuilen) die mogelijk tot een ijzertijdnederzetting behoren (ijzertijderven). Het meest duidelijke bouwplattegrond was dat van een twee-schepig gebouw

In de sporen werden in totaal 1357 scherven gevonden



# CAI - TIME

## ISSUES

- ▶ Only three levels are possible due to the implementation.
- ▶ All levels need to be present (lots of undetermined values in dropdowns).
- ▶ No real hierarchical capabilities. Entire hierarchy is stored in record, problematic if we want to change the hierarchy.

## ADVANTAGES

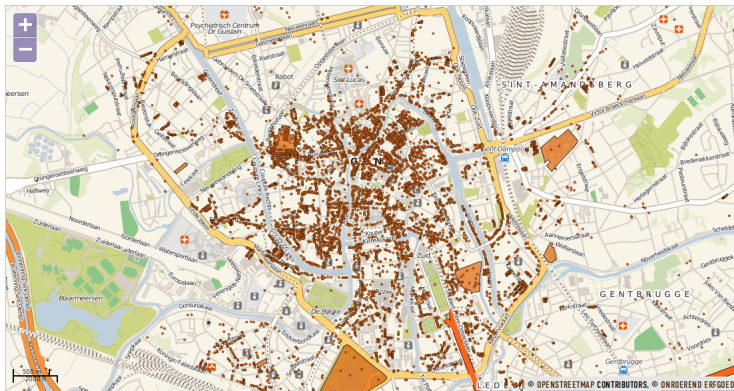
- ▶ Data entry is simple: pick three values from connected dropdowns
- ▶ Querying is very fast
- ▶ Can be implemented in MS Access



Ga naar een gemeente, straat of adres:

Geef een gemeente, straat of adres op.

Lagen kiezen



- GRB - Basiskaart
- GRB - Basiskaart (kleur)

#### OVERLAYS

- Geinventariseerd Bouwkundig Erfgoed
  - bouwkundige gehelen
    - vastgesteld
    - niet vastgesteld
  - bouwkundige relictten
    - vastgesteld
    - niet vastgesteld
- orgels



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# DIBE

- ▶ An inventory of some 81.000 architectural heritage records
- ▶ Used in spatial planning and heritage management
- ▶ Geospatial component
- ▶ Online reading and editing since 2009
- ▶ Some of the data came from older legacy systems
- ▶ Data: Medieval to now
- ▶ Same system is used for Parks and Gardens, Trees, ...

# DIBE - TIME

## COARSE PERIODS OF TIME

- ▶ Medieval > Early Medieval > Merovingian > Late Merovingian
- ▶ Newest Age > 20th century > Interwar period
- ▶ Newest Age > 19th century > 1st half 19th century > 1st quarter 19th century

## GRANULARITY

No need for very fine dates. Granularity does not even approach years.

## INDEXING

*When?* used as an indexing mechanism. There is no real dating going on here.

# DIBE - SEARCH FORM

## Een relict zoeken

### *Snel zoeken*

Naam

### *Geografisch zoeken*

Provincie

Gemeente

Deelgemeente

Straat

### *Thematisch-typologisch zoeken*

Typologie



Datering



Stijl



Persoon of Groepering

Zoeken

Zoekformulier Wissen

# DIBE - SEARCH RESULT

## Relicten



Je zoekopdracht leverde 77 resultaten.

Vorige [ [1](#) [2](#) [3](#) [4](#) ] [Volgende](#)



### [Parochiekerk Sint-Jan-Baptist](#)

**Afsneedorp 18, Gent (Oost-Vlaanderen)**

Parochiekerk St.-Jan-Baptist. Zeer schilderachtig gelegen plattelandserkerke aan de linker Leie-oever met gedeeltelijk ommuurd kerkhof en omringende beplanting. Eerste vermelding van een kerk in 939 doch vermoedelijk nog vroeger opklimmend daar Afsnee reeds bij de goederen van de St.-Pietersabdij vermeld werd onder koning Lotharius.



### [Parochiekerk Sint-Martinus](#)

**Baarledorpstraat zonder nummer, Gent (Oost-Vlaanderen)**

Oudste vermelding van de kerk van Baarle in 1025. Bouw van een nieuwe kerk na de opheffing van Baarle als zelfstandige gemeente.



### [Parochiekerk Sint-Elisabeth](#)

**Begijnhofdries zonder nummer, Gent (Oost-Vlaanderen)**

In 1242 kreeg gravin Johanna van de Schepenen van Gent een stuk grond ter vestiging van een begijnhof; de abt van Sint-Baafs stemt toe er een kapel op te richten. De Doornikse zuilen van de huidige kerk zijn vermoedelijke getuigen van deze eerste bouwfase doch archiefstukken ontbreken.

# DIBE - DETAIL

## Beknopte karakterisering

<b>Typologie:</b>	<a href="#">kerkhoven</a> , <a href="#">omheiningsmuren</a> , <a href="#">parochiekerken</a>
<b>Datering:</b>	<a href="#">13de eeuw</a> , <a href="#">derde kwart 18de eeuw</a> , <a href="#">eerste kwart 19de eeuw</a> , <a href="#">tweede helft 12de eeuw</a> , <a href="#">vierde kwart 15de eeuw</a> , <a href="#">vierde kwart 18de eeuw</a> , <a href="#">vóór WO I</a>

# DIBE - IMPLEMENTATION

## middeleeuwen (ID: 1227)

**Beknopte omschrijving** Verwijst naar de periode in West-Europa van grofweg de 5de tot de 15de eeuw. De verschillende stijlen die zich tijdens deze periode ontwikkelden kenmerken zich door de evolutie van de Grieks-Romeinse traditie naar een meer christelijke thematiek, door de energieke geest van de Germaanse volken en door de bloeiende nieuwe steden die werden bevolkt door vrije burgers.

**Bron** 1) Nederlandse Art & Architecture Thesaurus, <http://browser.aat-ned.nl/> 2) VIOE

**Termstatus** voorkeursterm

**Taal** nl-BE

**Meer algemene term** [Datering](#)

**Meer specifieke term(en)**

- [vroegere middeleeuwen](#)
- [volle middeleeuwen](#)
- [late middeleeuwen](#)

## THESAURUS

Implemented as a thesaurus of periods.

- ▶ Concepts



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**Meer specifieke term(en)**

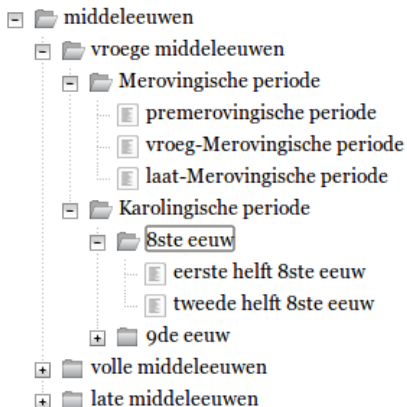
- [vroegge middeleeuwen](#)
- [volle middeleeuwen](#)
- [late middeleeuwen](#)

## THESAURUS

Implemented as a thesaurus of periods.

- ▶ Concepts
- ▶ Labels and notes
- ▶ Relations

# DIBE - IMPLEMENTATION

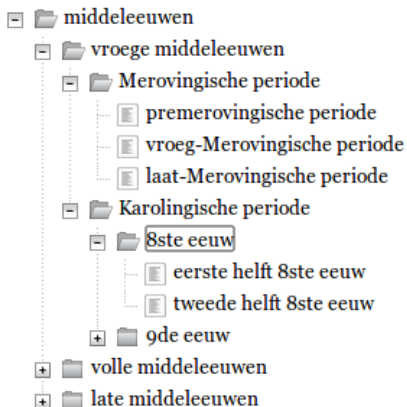


## THESAURUS

Implemented as a thesaurus of periods.

- ▶ Concepts
- ▶ Labels and notes
- ▶ Relations
- ▶ Strong focus on hierarchical relations

# DIBE - IMPLEMENTATION

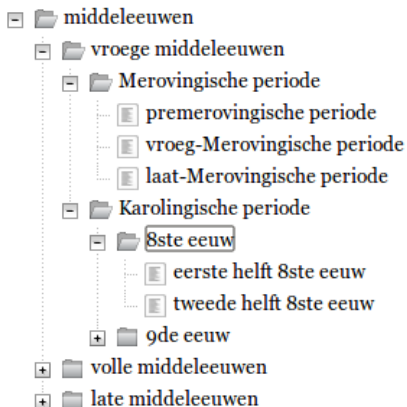


## THESAURUS

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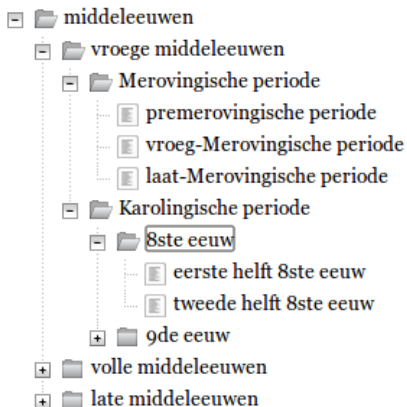
- ▶ Concepts
- ▶ Labels and notes
- ▶ Relations
- ▶ Strong focus on hierarchical relations
- ▶ Unbalanced Tree

# DIBE - IMPLEMENTATION



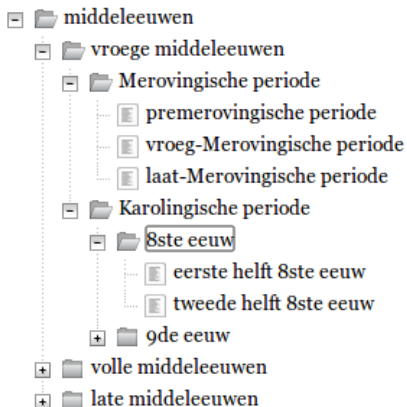
- ▶ At data entry only the most specific applicable period is indexed with the record (eg. 1st half 8th century)

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- ▶ At query time the query is expanded by the thesaurus. A search for 8th century becomes a search for 8th century, 1st half 8th century or 2nd half 8th century

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- ▶ At query time the query is expanded by the thesaurus. A search for 8th century becomes a search for 8th century, 1st half 8th century or 2nd half 8th century
- ▶ Recursive queries are expensive. Uses a nested set approach for retrieving the children of a certain period.

# DIBE - TIME

More or less the approach we took with archaeological heritage, but without a lot of the issues.

## ADVANTAGES

- ▶ Data entry is simple: pick a value from a tree
- ▶ Querying is very fast
- ▶ Depth of the period tree is unlimited
- ▶ Because hierarchical relations are calculated at query time, changing the hierarchy is not an issue
- ▶ Can be implemented in a good relational DBMS



# PERIOD BASED SYSTEMS

## HOW DO THEY DEAL WITH IMPERFECT TIME?

- ▶ Don't treat time as a special dimension
- ▶ Periods have no strict delimiters in the database
- ▶ Embraces the uncertainty
- ▶ For querying, quarter centuries are more than enough
- ▶ Doesn't matter if something was built in eg. 1805 or 1807

# PEOPLE

A dataset of people or organisations involved with heritage in Flanders: architects, organ builders, garden architects, ...

- ▶ A side product of the Architectural Inventory
- ▶ Data entry only started in 2009, based on an older list
- ▶ Contains a date of birth and a date of death
- ▶ Implemented as simple date fields based on user requirements

# PEOPLE

## PROBLEM

User requirements never specified that a person's date of birth and death could only be partially known. Quite often only a year is known, sometimes a month is known. PostgreSQL does not allow for partial dates.

## SOLUTION

Users enter the first of a month for a day in that month or the first of a year for a day in that year. Or nothing if the year is unknown.

- ▶ Somewhere in 1925 becomes *01-01-1925*
- ▶ No way to distinguish between born on *01-01-1925* and *somewhere in 1925*
- ▶ 41% of the people in our database have a potentially uncertain birth- or deathdate

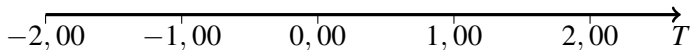
# A BETTER REPRESENTATION OF IMPERFECT TIME

Our handling of the historic people case left us rather unsatisfied. So we turned to academic literature to try and find a better solution.

## FROM POINT TO INTERVAL

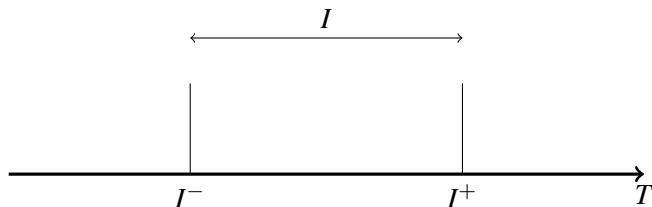
We realised that although we always talk about a date of birth and a date of death, what we really are interested in is someone's lifespan. The main question is not: "Who was born in 1845?", but "Who was alive in 1845?".

# TIMELINE



- ▶ Timeline T
- ▶ Infinity in both directions
- ▶ Point  $t$  = real number
- ▶  $TP(d) = t$
- ▶  $TP(1 \text{ january } 3 \text{ BC}) = -2,00$
- ▶  $TP(1 \text{ january } 2 \text{ BC}) = -1,00$
- ▶  $TP(1 \text{ january } 1 \text{ BC}) = 0,00$
- ▶  $TP(1 \text{ january } 1 \text{ AD}) = 1,00$
- ▶  $TP(1 \text{ january } 2 \text{ AD}) = 2,00$

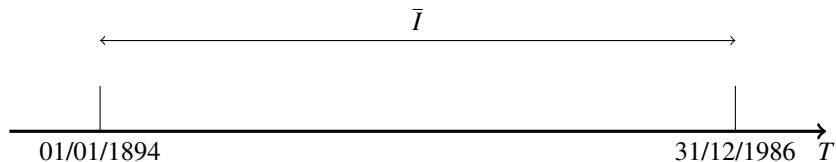
# SHARP TIMEINTERVAL (STI)



- ▶ A set as we generally know it
- ▶ *membership function*  $A : U \rightarrow \{0, 1\}$ .
- ▶  $A(x) = 1$  if  $x \in A$  and  $A(x) = 0$  if  $x \notin A$ .

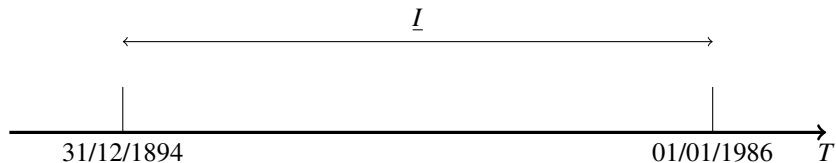
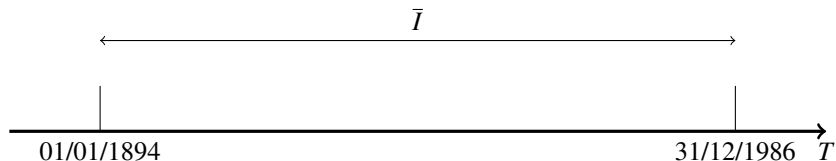
# EXAMPLE

Karel Aubroeck was born in 1894. He died in 1986.



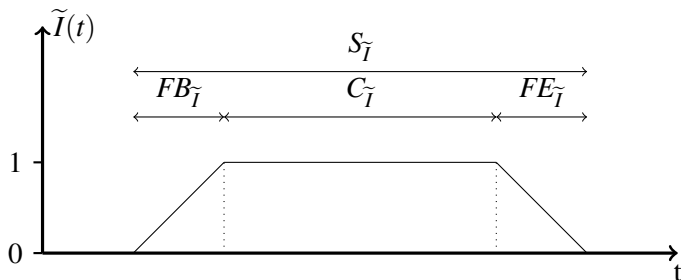
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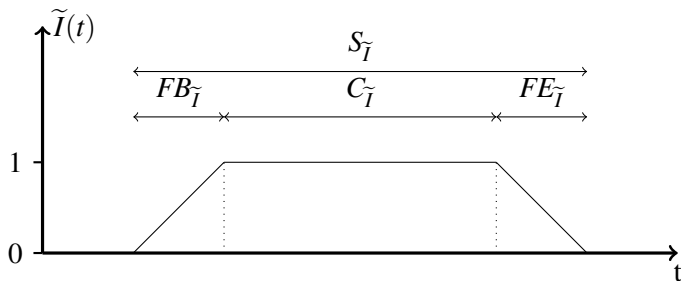


## FUZZY TIMEINTERVAL (FTI)



- ▶ Core  $C_{\tilde{I}}$
- ▶ Support  $S_{\tilde{I}}$
- ▶ Fuzzy beginning  $FB_{\tilde{I}}$
- ▶ Fuzzy end  $FE_{\tilde{I}}$

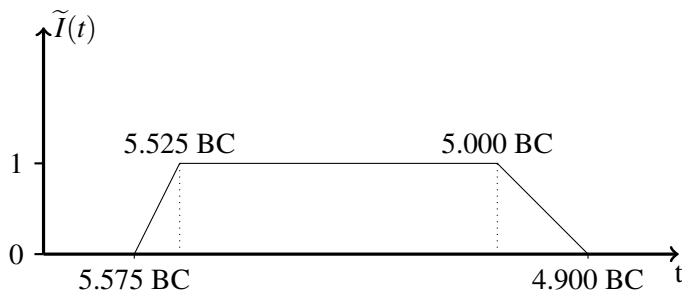
## FUZZY TIMEINTERVAL (FTI)



- ▶ A fuzzy set
- ▶ *membership function*  $A : U \rightarrow [0, 1]$ .
- ▶  $A(x) = 1$  if we are sure  $x \in A$
- ▶  $A(x) = 0$  if we are sure  $x \notin A$
- ▶  $A(x) = ]0, 1[$  if we know  $x$  might be  $\in A$
- ▶ The value of  $A(x)$  determines to what degree  $x$  is part of the set

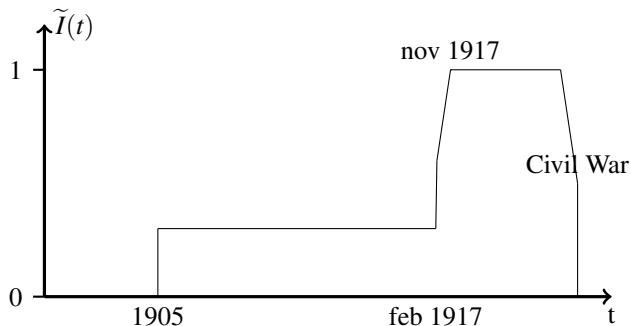
# EXAMPLES

Linear Pottery Culture in Flanders started around 5.550 BC. It disappeared between 5.000 and 4.900 BC.



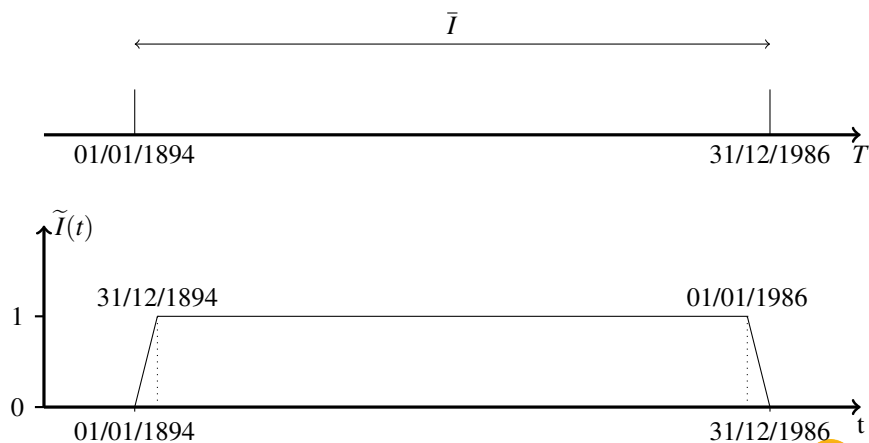
## EXAMPLES

The Russian Revolution was a series of smaller revolutions: one in 1905, the february revolution and october revolution in 1917 and a civil war from 1918 to 1922-1923.



# SHARP VS. FUZZY EXAMPLE

Karel Aubroeck was born in 1894. He died in 1986.

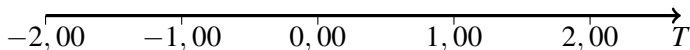


# HOW CAN WE COMPARE TIME?

## HOW CAN WE COMPARE TIME?

- ▶ Granularity: date
- ▶ Relation between timepoints?
- ▶ Relations between STI's?
- ▶ Relations between FTI's?

# RELATIONS BETWEEN TIMEPOINTS



- ▶ Every date corresponds to a point on  $T$
- ▶ We can order them.
- ▶ For 2 points:  $A$  and  $B$
- ▶ before:  $A < B$
- ▶ equals:  $A = B$
- ▶ after:  $A > B$
- ▶ Result is boolean: true or false.

## ALLEN RELATIONS FOR SHARP TIME INTERVALS

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before	$b(A, B) \equiv a^+ < b^-$
overlaps	$o(A, B) \equiv a^- < b^- \wedge b^- < a^+ \wedge a^+ < b^+$
during	$d(A, B) \equiv a^- > b^- \wedge a^+ < b^+$
meets	$m(A, B) \equiv a^+ = b^-$
starts	$s(A, B) \equiv a^- = b^- \wedge a^+ < b^+$
finishes	$f(A, B) \equiv a^+ = b^+ \wedge b^- < a^-$
equals	$e(A, B) \equiv a^- = b^- \wedge a^+ = b^+$

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- ▶ Table only shows half of the relations. Most relations can be reversed.
- ▶  $before(A, B) = after(B, A)$
- ▶ Only *equals* has no reverse.  $equals(A, B) = equals(B, A)$
- ▶ Result is boolean: true or false.
- ▶ Relations defined between the begin- and endpoints of 2 STI's.





# FUZZY ALLEN RELATIONS

## HOW CAN WE DEFINE THE ALLEN RELATIONS FOR 2 FTI'S?

- ▶ The relation between 2 FTI's is a fuzzy relation
- ▶ *temporal relation BEFORE* :  $\tilde{I}x\tilde{I} \rightarrow [0, 1]$ .
- ▶  $BEFORE(a, b) = 1$  if we are sure  $a$  came before  $b$
- ▶  $BEFORE(a, b) = 0$  if we are sure  $a$  came after  $b$
- ▶  $BEFORE(a, b) = ]0, 1[$  if we know  $a$  might have come before  $b$
- ▶ The value of  $BEFORE(a, b)$  determines to what degree  $a$  came before  $b$ .

# FUZZY ALLEN RELATIONS

## NAGYPÁL AND MOTIK (NM)

- ▶ Nagypál, G. and Motik B. (2003). A fuzzy model for representing uncertain, subjective and vague temporal knowledge in ontologies. In Proc. of the Int. Conf. on Ontologies, Databases and Applications of Semantics, pp. 906–923.
- ▶ Intuitive results
- ▶ Fully compatible with Allen relations for STI's
- ▶ Not suitable for temporal reasoning
- ▶  $equals(A, A) = 0.5$  instead of  $equals(A, A) = 1$
- ▶  $starts(A, A) = finishes(A, A) = during(A, A) = 0.5$  instead of 0
- ▶ only works for convex FTI's.

# FUZZY ALLEN RELATIONS

## SCHOCKAERT (*SI*)

- ▶ S. Schockaert, M. De Cock & E. E. Kerre. Fuzzifying allen's temporal interval relations. IEEE T. Fuzzy Systems, 16(2), 517–533 (2008)
- ▶ Intuitive results
- ▶ Complex calculation
- ▶ Fully compatible with Allen relations for STI's
- ▶ Suitable for temporal reasoning
- ▶  $equals(A, A) = 1$

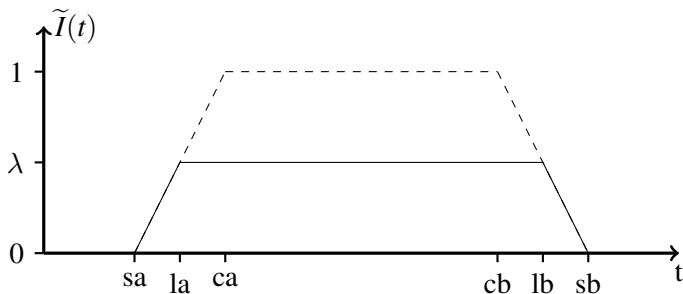
# FUZZY ALLEN RELATIONS

## SCHOCKAERT (S2)

- ▶ S. Schockaert, M. De Cock & E. E. Kerre. An efficient characterization of fuzzy temporal interval relations. In Proceedings of the 2006 IEEE World Congress on Computational Intelligence, 9026–9033 (2006)
- ▶ Specialised version of S1
- ▶ Simpler to calculate
- ▶ Only works for trapezoidal FTI's.

## FUZZY ALLEN RELATIONS

## SCHOCKAERT (S2)



- ▶ Can be represented by 4 points:  $sa$ ,  $ca$ ,  $cb$ ,  $sb$  and  $\lambda$
- ▶ If  $\lambda < 1$  then there are no points that we are sure of are part of the set



# IMPLEMENTATION

- ▶ Implementation in a RDBMS, Postgresql
- ▶ Using PostGIS (Spatial extension)
- ▶ Written in *SQL* and *PL/pgSQL*
- ▶ Code released as Open Source Software under an MIT license.
- ▶ Download at <https://github.com/koenedaele/pgFTI>
- ▶ Records a FTI as a geometry.
- ▶ Provides API methods for creating these geometries.
- ▶ Provides API methods for calculating the allen relations between 2 FTI's according to the NM and S2 methods.

# TESTING THE ALLEN BEFORE RELATION

Date	NM		S1		S2	
	n	time (sec)	n	time (sec)	n	time (sec)
01/01/1001	0	0,023	0	0,006	0	0,006
01/01/1701	15	0,029	15	3,766	15	0,007
01/01/1901	228	0,259	228	184,931	228	0,019
01/01/2101	1280	0,007	1280	0,294	1280	0,005

- ▶ Each methode produces the same outcome.
- ▶ S1 is the slowest by far.
- ▶ Effect of short-circuiting.
- ▶ S2 is faster than NM.

# HERITAGE EVENTS

Another utility dataset. Contains events such as an excavation, a survey, ...  
Who did what when to a certain site or heritage object?

Our first implementation of FTI's in a production environment.

We use simple trapezoidal FTI's.

- ▶ Can capture enough imperfection
- ▶ Performance matters



# CHALLENGE

## DATA ENTRY

How to enter Fuzzy Temporal Intervals in a user-friendly way?

- ▶ Users don't think in (sharp or fuzzy) temporal intervals
- ▶ Users think in natural language
- ▶ How can we enter this information and keep it editable?
- ▶ What to put on a report? Users do not want to see a Fuzzy Temporal Interval. They want something they can easily read and understand.

## DATING A HERITAGE EVENT

Maand	▼	Dag	▼
December	▼	2013	▲ ▼
December 2013		10-01-2014	▼
December 2013		10-01-2014	
December 2013 - 10-01-2014			

## DETAIL OF A HERITAGE EVENT

### Algemeen

<b>Locatie</b>	Onbepaald
<b>Type:</b>	<a href="#">dateringsonderzoek</a>
<b>Datum:</b>	December 2013 - 10-01-2014
<b>Resultaat:</b>	heeft relevante informatie opgeleverd
<b>Opmerkingen:</b>	
<b>Verdere informatie:</b>	
<b>In GIS:</b>	Nee

# IN THE DATABASE

```
SELECT id, titel, ST_AsText(periode_vti), periode_metadata
FROM deo.gebeurtenis WHERE id = 986;
```

```

-[ RECORD 1 ]-----+-----
id            | 986
titel         | Paris Conference on Temporal Information
st_astext     | LINestring(2013.91506849315 0,2013.99726027397
              | 1,2014.02465753425 1,2014.02465753425 0)
periode_metadata | (2013-12-01,2013-12-31,2014-01-10,2014-01-10,
              | maand , dag , "December_2013" ,10-01-2014,f , f ,
              | "December_2013_10-01-2014")

```

# QUERY EXAMPLE

```
SELECT
  titel ,
  FD_NM_allen_during(
    periode_vti , FD_maakVoorstelling ( '1978-09-14' :: date , '1983-09-14' :: date )
  ) AS allen_during ,
  (periode_metadata). omschrijving
FROM deo.gebeurtenis
WHERE
  periode_vti IS NOT NULL AND
  FD_NM_allen_during(
    periode_vti , FD_maakVoorstelling ( '1978-09-14' :: date , '1983-09-14' :: date )
  ) > 0;
```

# QUERY EXAMPLE

titel	allen_during	omschrijving
Mijn opgraving	0.2967032967	1978 – Augustus 1980
Inventarisatie De Panne	1	01-01-1982 – 28-05-1982
Inventarisatie Veurne	1	01-01-1982 – 28-05-1982
inventarisatie Mechelen 9n	1	01-01-1982 – 31-12-1982
inventarisatie Sint-Niklaas	1	01-01-1981 – 31-12-1981

## FURTHER WORK ON UI

Current User Interface is a good starting point, but can be expanded

- ▶ Option to use *century*
- ▶ Option to use *decade*
- ▶ Option to use *arbitrary periods*
- ▶ Be able to enter an *In ...* period next to the current *From ... to ...* period

## A CUSTOM C EXTENSION

If we want to go further with FTI's, we need to be able to query them as fast as possible.

- ▶ PostgreSQL is highly customisable and extendable
- ▶ Implementing trapezoidal FTI's as an extension (written in C)
- ▶ Removes the dependency on PostGIS
- ▶ Similar API to the PL/pgSQL version
- ▶ Ability to add operators

```
SELECT * FROM persoon
WHERE sfti << sfti_makeSFTI( 'now' :: date );
```



## PERFORMANCE COMPARISON

Date	NM		S2		SFTI	
	n	time (sec)	n	time (sec)	n	time (sec)
01/01/1001	0	0,023	0	0,006	0	0,0025
01/01/1701	15	0,029	15	0,007	15	0,0032
01/01/1901	228	0,259	228	0,019	228	0,0034
01/01/2101	1280	0,007	1280	0,005	1280	0,0028

- ▶ Tests based on alpha version
- ▶ About 1,5 to 5 times as fast as the postGIS implementation

# INDEXING

## INDEXING FRAMEWORK

PostgreSQL offers extensible index frameworks. Ability to define GIST, GIN and SP-GIST indexes.

```
CREATE INDEX ON persoon USING GIST( sfti );
```

By leveraging this framework we could use FTI's with very large datasets. So we can avoid full sequential table scans.

# CONCLUSION

- ▶ No true one way to deal with temporal information.
- ▶ Users prefer the period based approach for heritage objects.
- ▶ Consider the use case and build something that's good enough to satisfy the business requirements.
- ▶ Still a lot of progress to be made.

## FURTHER INFORMATION

### FURTHER READING AND FULL BIBLIOGRAPHY

Koen Van Daele, 2010: *Imperfecte tijdsmodellering in historische databanken*. Unpublished masterpaper, Universiteit Gent [http://lib.ugent.be/fulltxt/RUG01/001/418/820/RUG01-001418820\\_2010\\_0001\\_AC.pdf](http://lib.ugent.be/fulltxt/RUG01/001/418/820/RUG01-001418820_2010_0001_AC.pdf).

### ENGLISH SUMMARY

Koen Van Daele, 2013: *Modelling Imperfect Time in Datasets*. In: G. Earl, T. Sly, A. Chrysanthi, P. Murrieta-Flores, C. Papadopoulos, I. Romanowska and D. Wheatley (eds). *Archaeology in the Digital Era. Papers from the 40th Annual Conference of Computer Applications and Quantitative Methods in Archaeology (CAA)*, Southampton, 26-29 March 2012.

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