

On Reasoning on Time and Location on the Web

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Temporal Reasoning: A motivating Example

Example: web-based appointment scheduling

Three businessmen (one in London, one in Athens, and one in Tokyo) plan a *phone conference* to take place in the *week after Easter*.

- temporal primitives in various time granularities
- calendar systems and time zones
- sociocultural temporal notions

Locational Reasoning: A motivating Example

Example: web-based information service

Where is an *open* pharmacy in *downtown Munich*?

- locational primitives of various location granularities
- means of transportation and topological aspects
- related temporal context

Motivation

- observation
 - temporal data (time points, time intervals, durations specified in different granularities of various calendars) can be found (implicitly or explicitly) all over the Web
 - locational data frequently interwoven with temporal data
 - Semantic Web and advanced Web applications like adaptive Web systems and mobile computing
 - heterogeneity of the Web
 - internationalization and localization efforts on the Web
- essential building block for the Web: query and transformation languages like the W3C recommendations XQuery and XSLT, and the logic-based language Xcerpt (ongoing research project)

Proposal

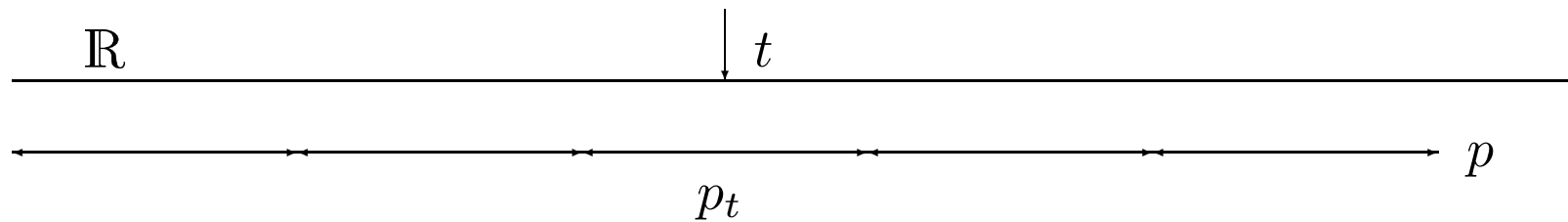
⇒ **Web languages, especially query and transformation languages, lack temporal as well as locational types and reasoning capabilities**

Temporal and Locational Type Systems with reasoning capabilities integrated into Web Languages

The computation engine: WebCal

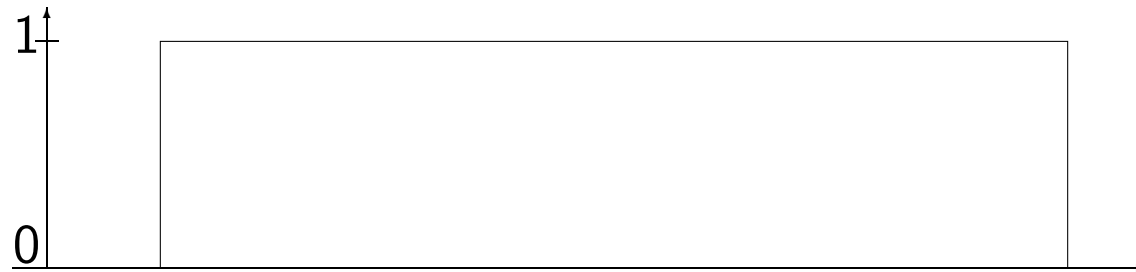
- Web server for calendrical calculations
- supports different calendar systems with their particularities
- data structure: times are mapped to (poss. fuzzy) time interval (i.e. partitionings of the reference timeline)
- provides basic temporal operations over (poss. fuzzy) time intervals

WebCal: Partitionings

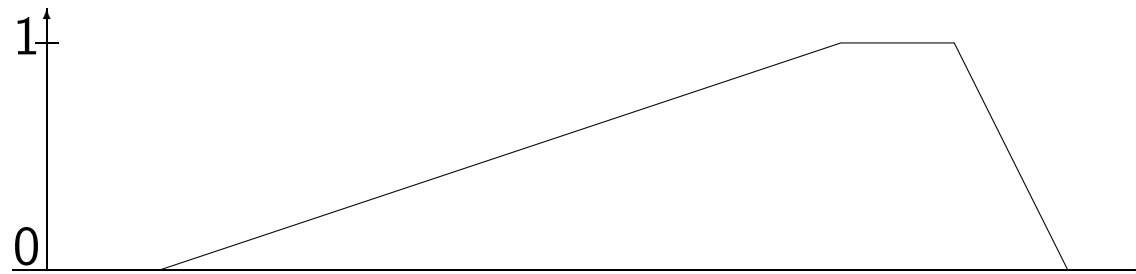


partitioning of the reference timeline according to calendar and clock systems in terms of time granularities in the common manner

WebCal: Time Intervals



crisp interval: Dec. 8th 2003



fuzzy interval: towards evening

WebCal: Operations over Time Intervals

- turning crisp intervals to fuzzy intervals
- usual set-theoretic operations
- usual interval relations, e.g. before, overlaps
- shifting, e.g. 3 months, 2 days
- within, e.g. 1st day within week, last day within year

Xcerpt: A Query Language for the Web

Xcerpt (currently developed and tested on web-based systems at the University of Munich):

- logic-based query and transformation language
- paradigms: SQL and logic programming
- uses instead of (a form of) pattern matching a (non-standard) form of unification, called simulation unification

Xcerpt plus temporal constructs and temporal reasoning capabilities:

- based on algebraic time model with time granularities
- temporal primitives (time point, time interval, duration) with temporal context and their respective temporal operations integrated into Xcerpt
- basic temporal computation of the operations is based on WebCal

Xcerpt: An Example Database Term

Assuming a movie program as an XML document. This XML document may look like as follows (in Xcerpt syntax):

```
cinema_program {
  attributes { week { "[2003-06-19,2003-06-26]" } }
  cinema {
    attributes { name { "Leopold" } }
    movie {
      title { "Lampedusa" }
      begin { "20:15" }
      duration { "P90M" }
      room { "1" }
    }
    movie {
      title { "City of God" }
      begin { "22:15" }
      duration { "P135M" }
      room { "2" }
    }
  }
}
cinema {
  attributes { name { "Atlantis" } }
  movie {
    title { "City of God" }
    begin { "21:00" }
    duration { "P135M" }
  }
}
...
}
```

Xcerpt: An Example Query

'Is there a show of "City of God" on 21st June 2003 that begins between 22:00 and 23:00? List the cinemas and the beginning times!'

```
LET
  calendar = gregorian;
  timezone = UTC + 1;
  granularity = minute;
  LET granularity = day IN var Week::TimeInterval END
  LET anchor = 2003-06-21 IN var Begin::TimePoint END
IN
  CONSTRUCT
    results { result all { cinema {attributes
                                   {name { var Name }
                                   begin { var Begin } } }
  FROM
    cinema_program {{
      attributes {{ week { var Week } }}
      cinema {{
        attributes {{ name { var Name } }}
        movie {{
          title { "City of God" }
          begin { var Begin }
        }}
      }}
    }}
  WHERE
    belongs_to(2003-06-21, Week),
    belongs_to(Begin, [2003-06-21T22:00, 2003-06-21T23:00])
END
```

Status of the Project

- Xcerpt: Simulation Unification [ICLP 2002], chaining, running prototype since 2002, www.xcerpt.org
- computing/reasoning engine WebCal
- temporal constructs and operations currently defined (in process: formalization of the type system)
- in process: integration of this type system into Xcerpt and its connection to WebCal
- applications (as test bed) currently investigated

Future Work

- static (and dynamic) type checking
- granularity and calendar aware constraint reasoning
- development of location type system and computation engine for locational reasoning