

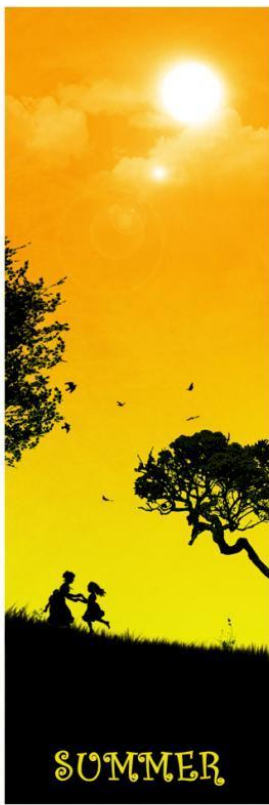


Vis 2013
VAST • INFOVIS • SCIVIS
BIOVIS • LDAV

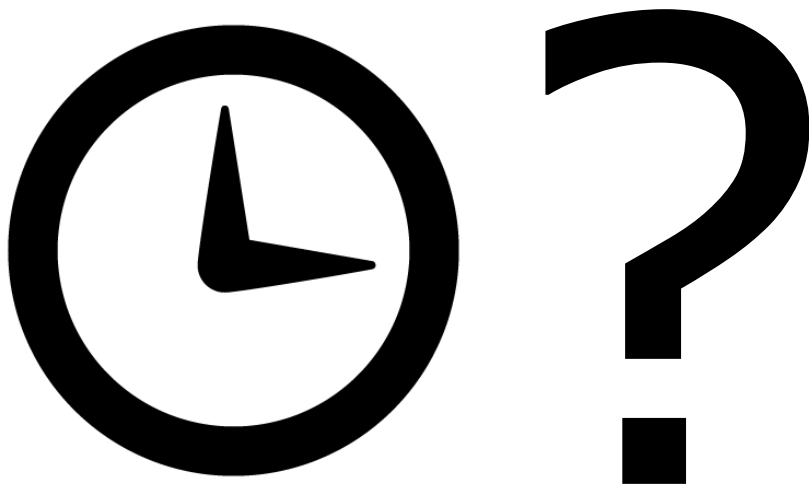


TimeBench: A Data Model and Software Library for Visual Analytics of Time-Oriented Data

Alexander Rind, Tim Lammarsch, Wolfgang Aigner, Bilal Alsallakh, and Silvia Miksch
Vienna University of Technology, Inst. Software Technology & Interactive Systems



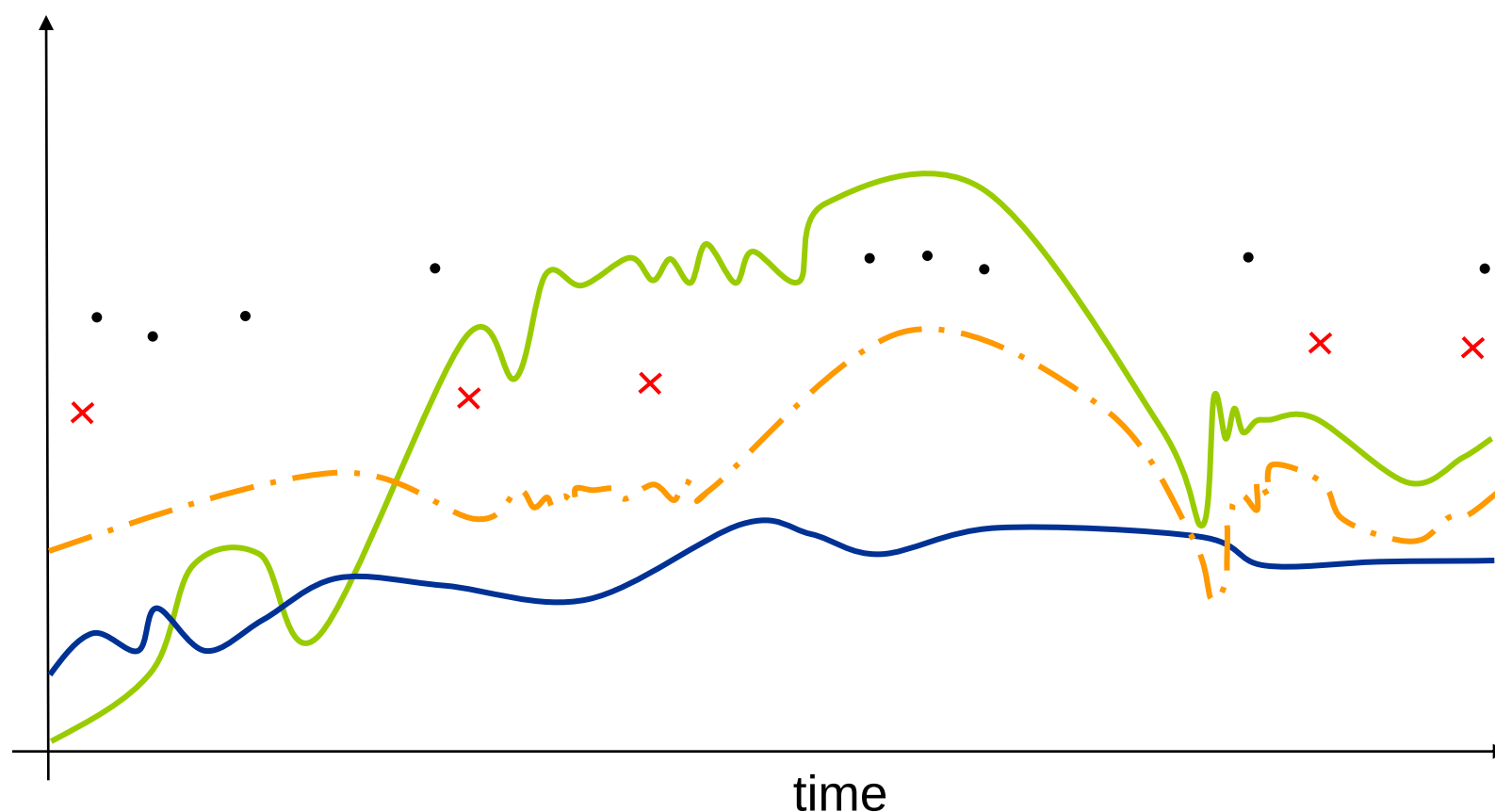
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Tue	Fri	Fri	Mon	Wed	Sat	Mon	Thur	Sun	Tue	Fri	Sun	2, 9, 16, 23, 30
Wed	Sat	Sat	Tue	Thur	Sun	Tue	Fri	Mon	Wed	Sat	Mon	3, 10, 17, 24, 31
Thur	Sun	Sun	Wed	Fri	Mon	Wed	Sat	Tue	Thur	Sun	Tue	4, 11, 18, 25
Fri	Mon	Mon	Thur	Sat	Tue	Thur	Sun	Wed	Fri	Mon	Wed	5, 12, 19, 26
Sat	Tue	Tue	Fri	Sun	Wed	Fri	Mon	Thur	Sat	Tue	Thur	6, 13, 20, 27
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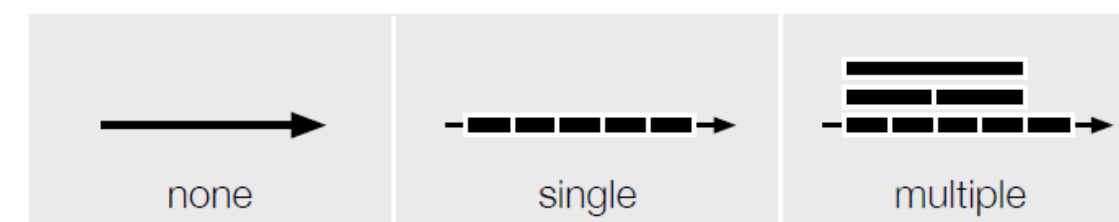
Challenges of Time-oriented Data

e.g., analyzing electronic health records

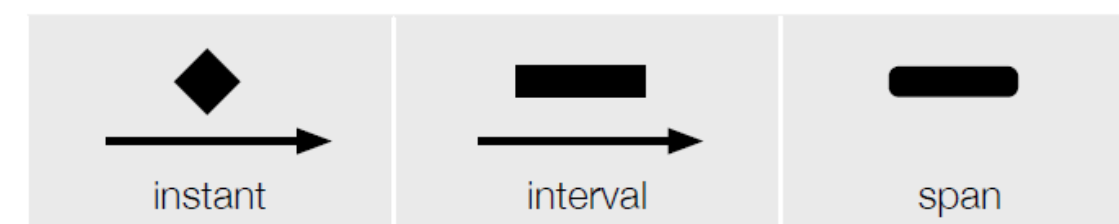
time-oriented multivariate sampled irregularly



multiple granularities & cycles



different time primitives



temporal indeterminacy



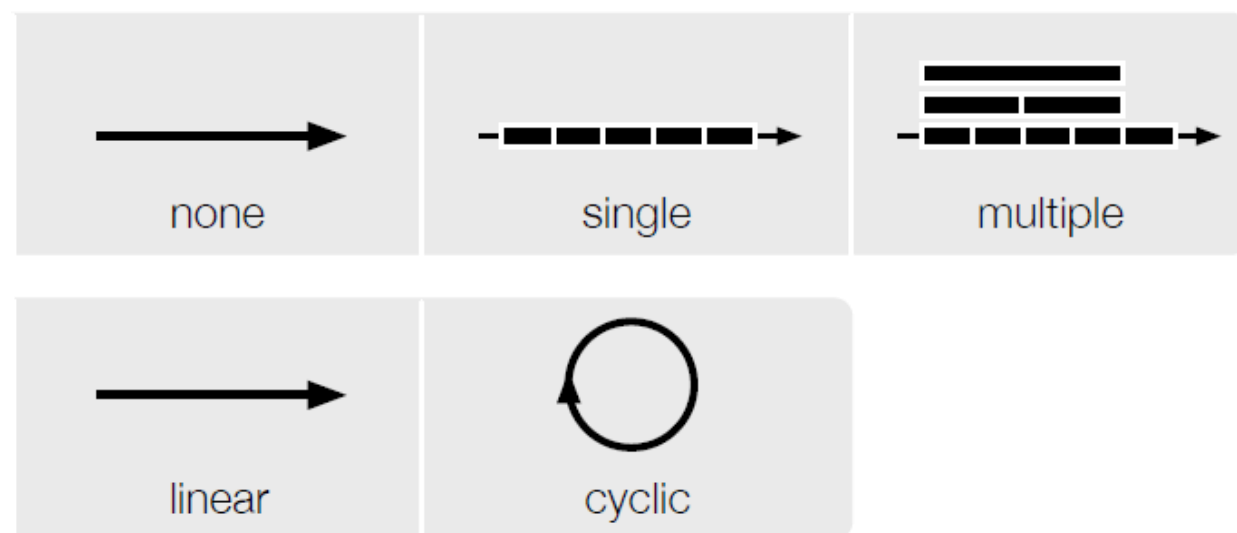
A Software Library for Visual Analytics

TimeBench aims to fulfill the following desiderata:

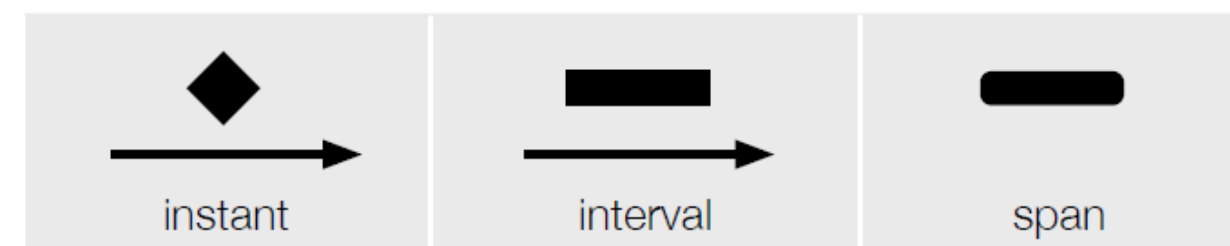
- expressiveness
- common data structure
- developer accessibility
- runtime efficiency

Aspects of Time-oriented Data

multiple granularities & cycles



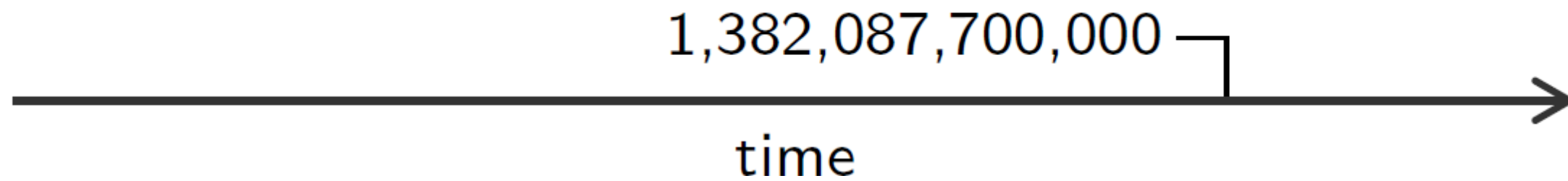
different time primitives



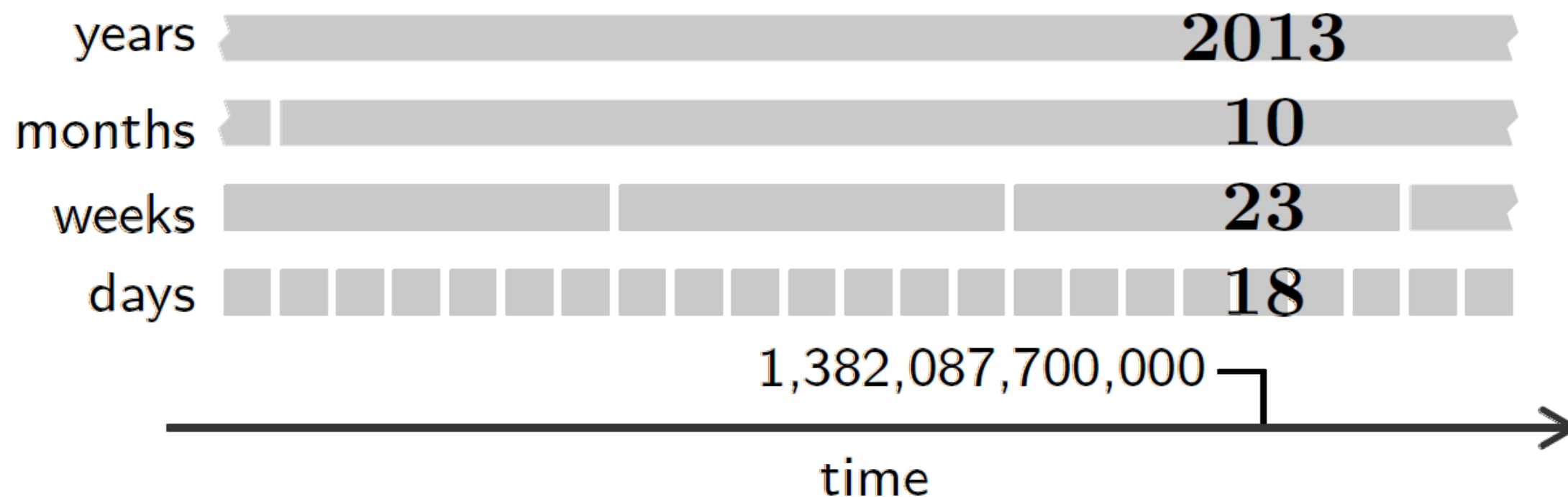
temporal indeterminacy



Challenging Aspect: Multiple Granularities & Cycles

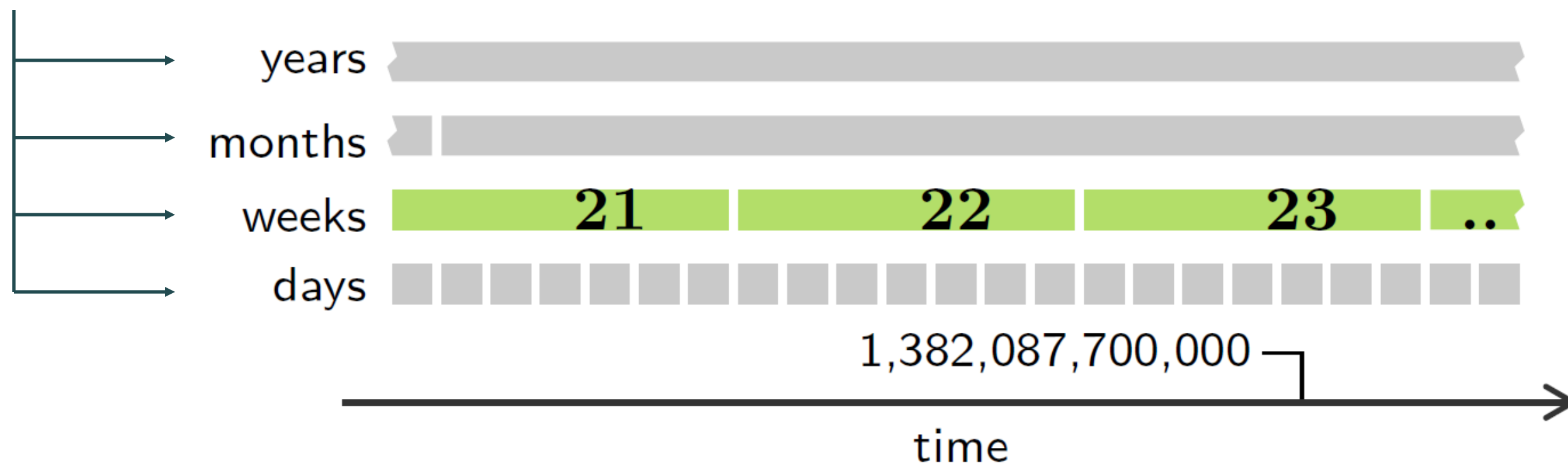


Calendar Operations for Granularities



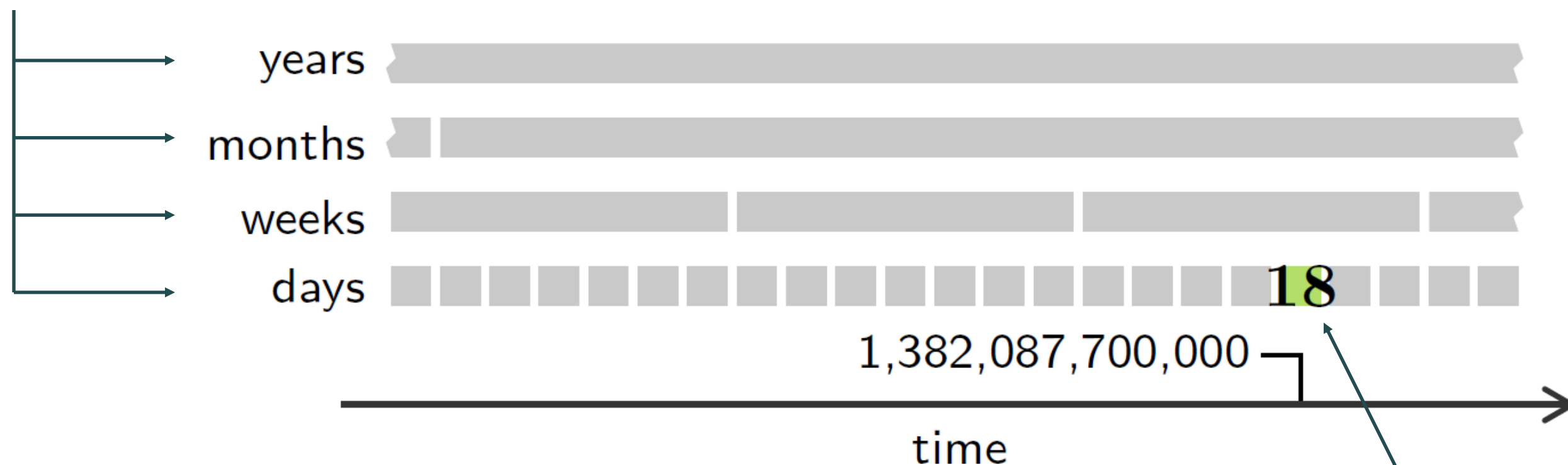
Calendar Operations for Granularities

granularities ... map time and integer numbers



Calendar Operations for Granularities

granularities ... map time and integer numbers



granule ... subset of time for a granularity and an identifier

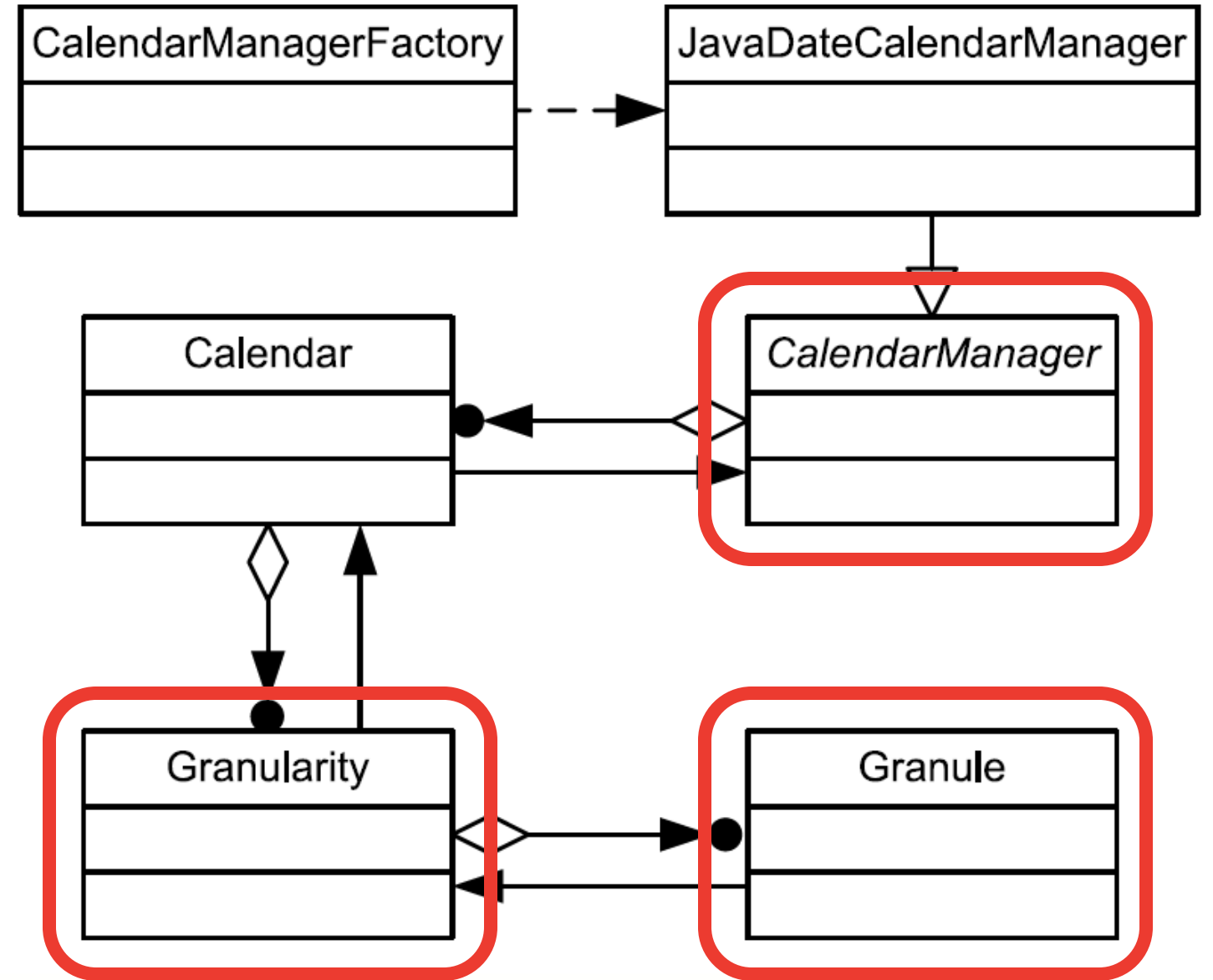
Calendar package

general classes

- Granule
- Granularity

exchangeable calendar backend

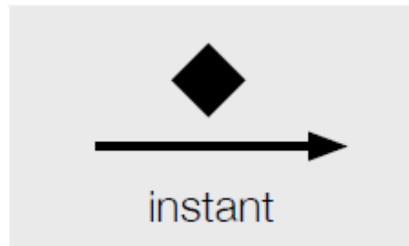
- CalendarManager



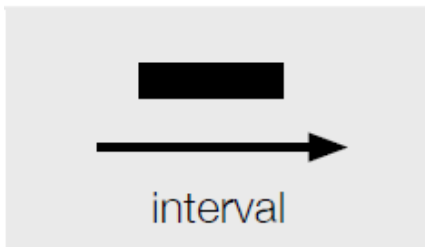
Calendar Operations based on Granularities

- anchor data on any granularity
- convert granules to another granularity
convert milliseconds (and vice versa)
- group granules by identifier
- shifting granules by a given number
- check qualitative temporal relations

Challenging Aspect: Different Time Primitives



1 time point



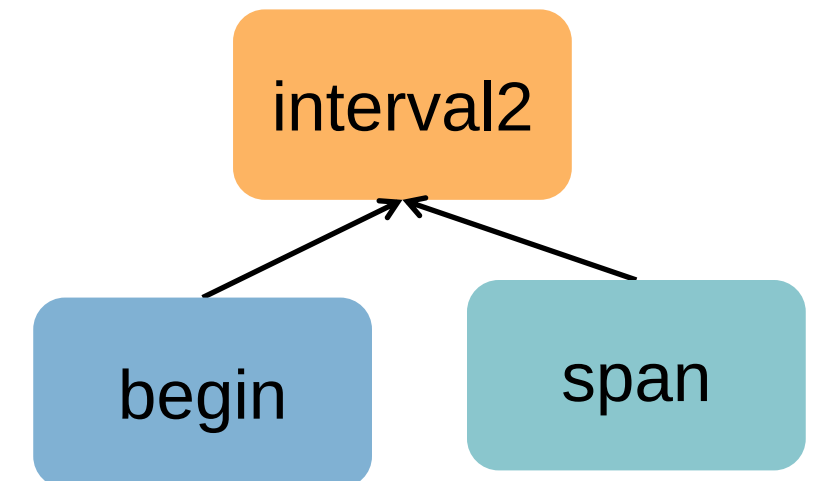
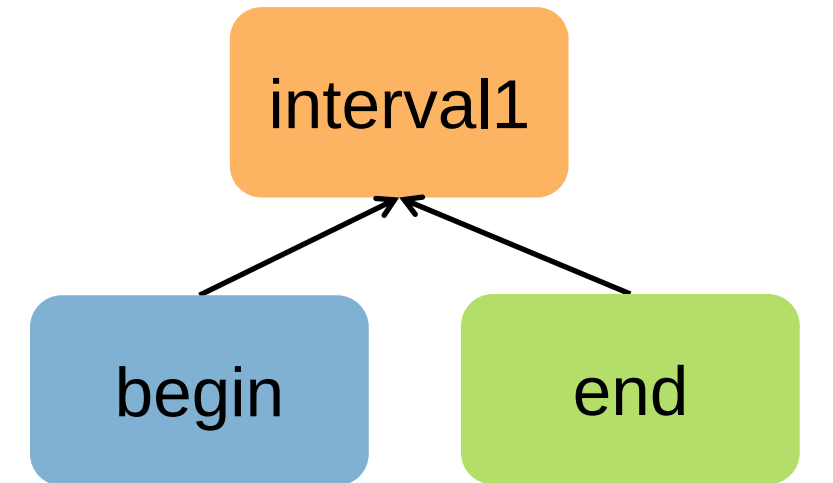
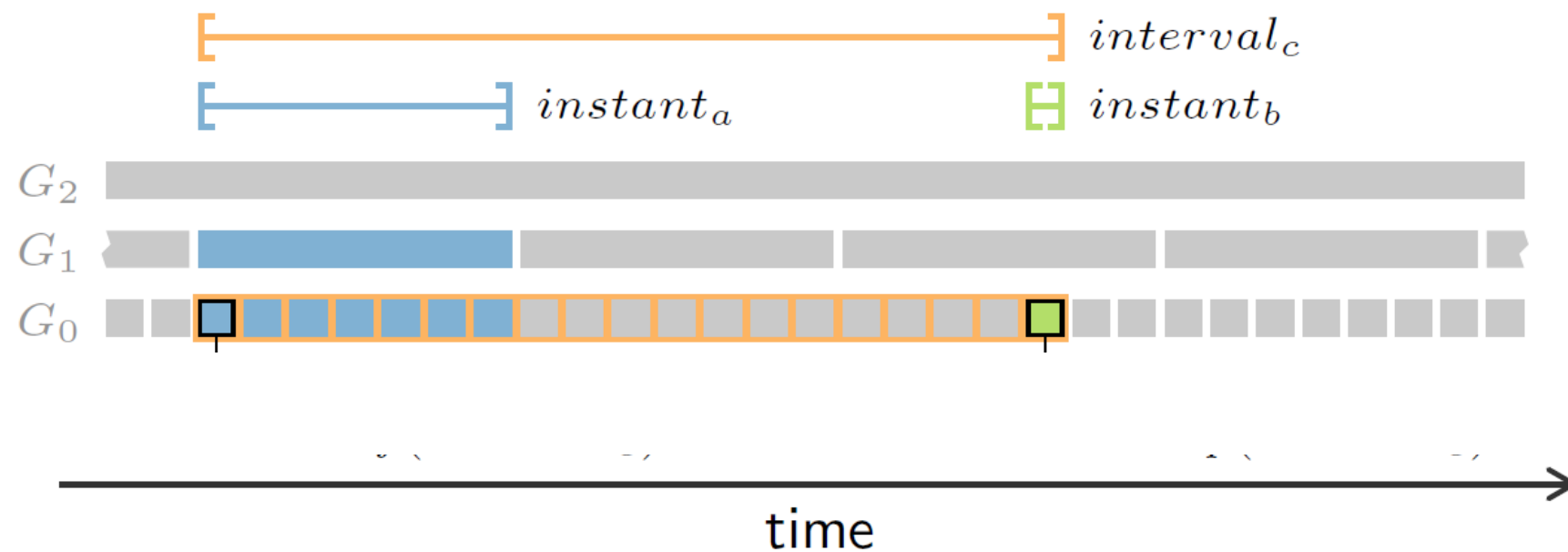
period between 2 time points



duration of a period (not anchored in time)

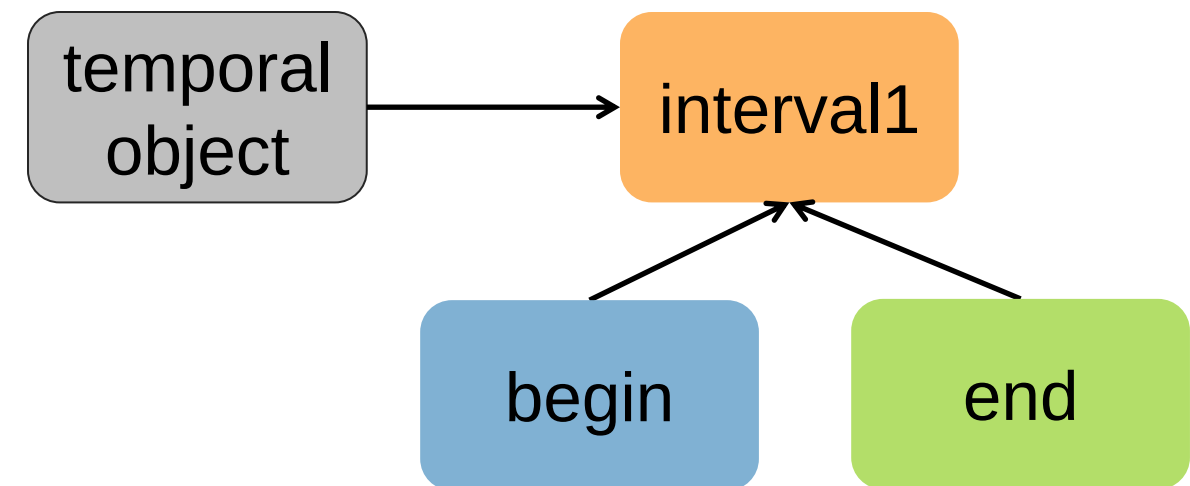
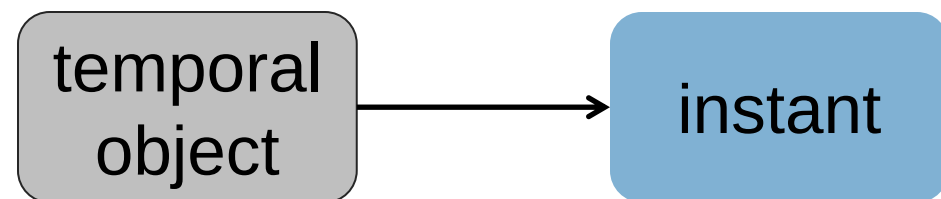
Expressive Data Structure for Primitives

complex primitives built hierarchically
create primitives from granules
object-oriented tuples



Connecting Data to Primitives

temporal object ... data tuple with a reference to a primitive



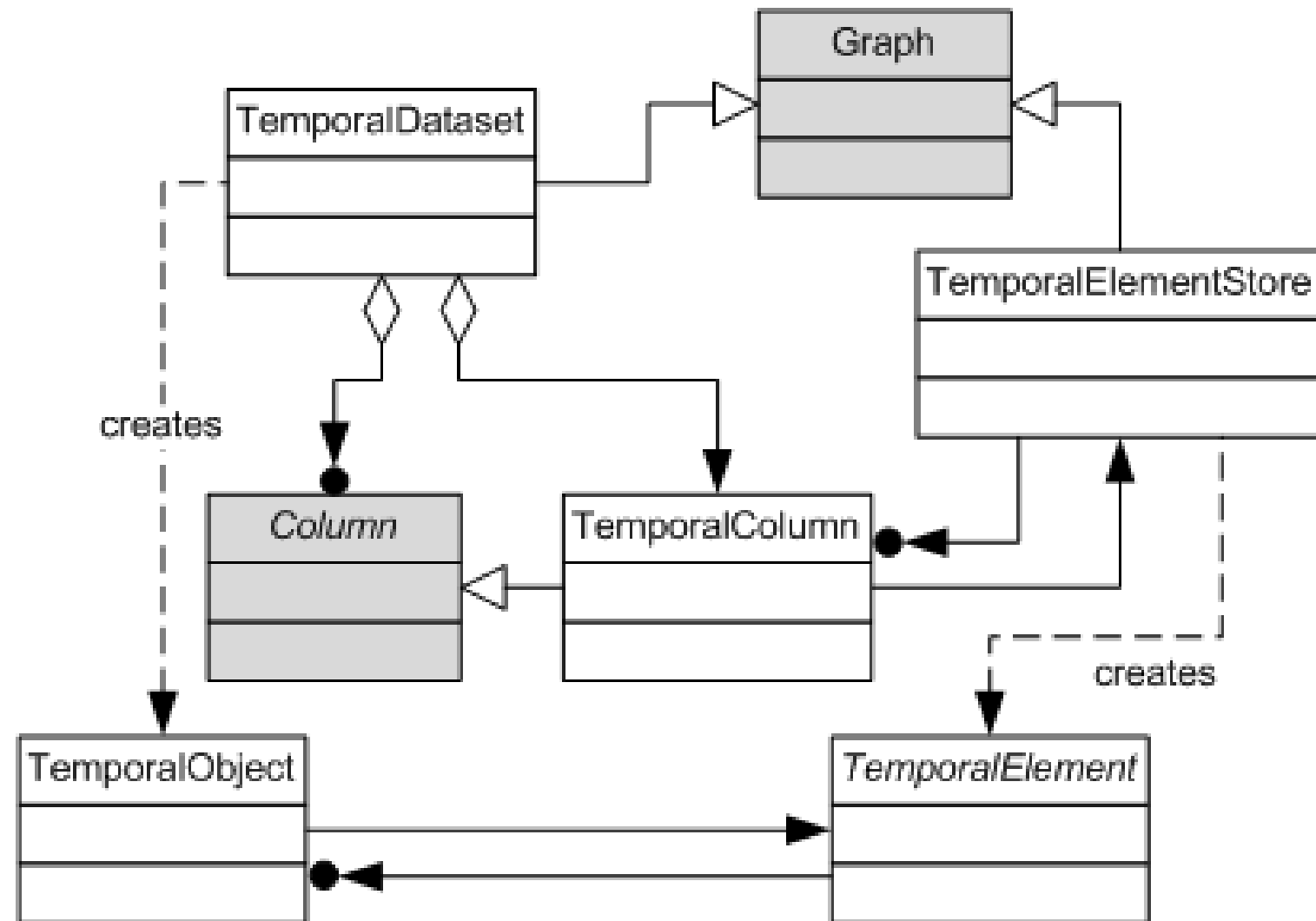
```
Primitive p = object.getPrimitive();  
if (p instanceof Interval)  
    print p.getBegin();  
foreach (obj : p.getObjects())  
    print obj;
```

Embedded in Software Design Patterns

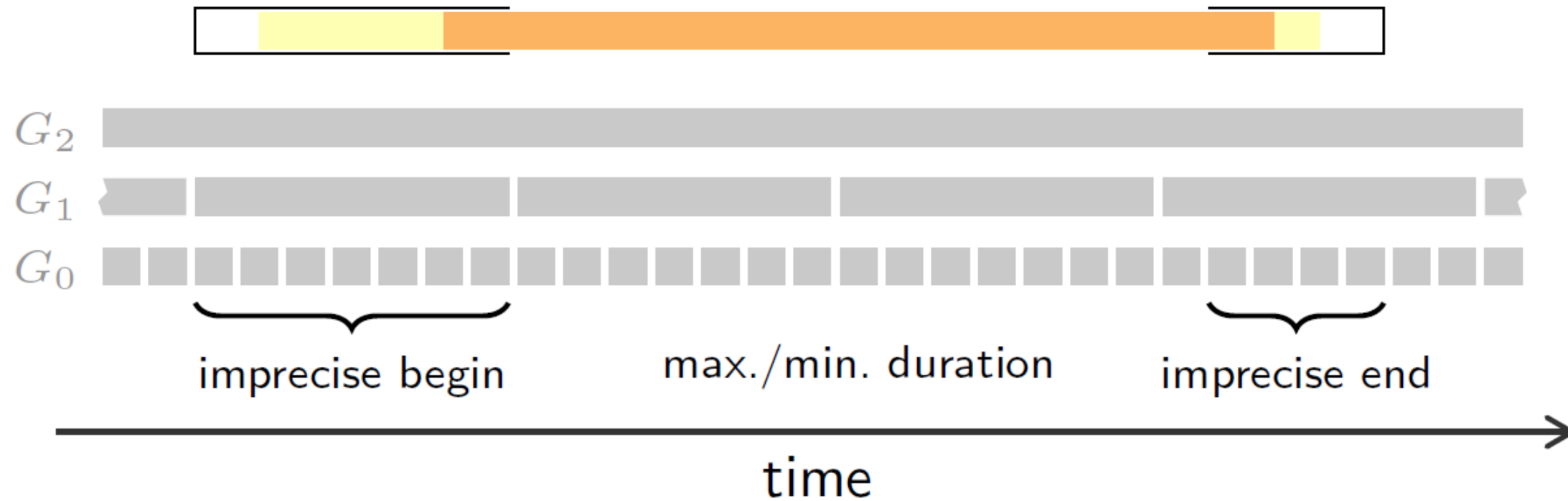
data column pattern
relational graph pattern
proxy tuple pattern

factory methods
accessor methods

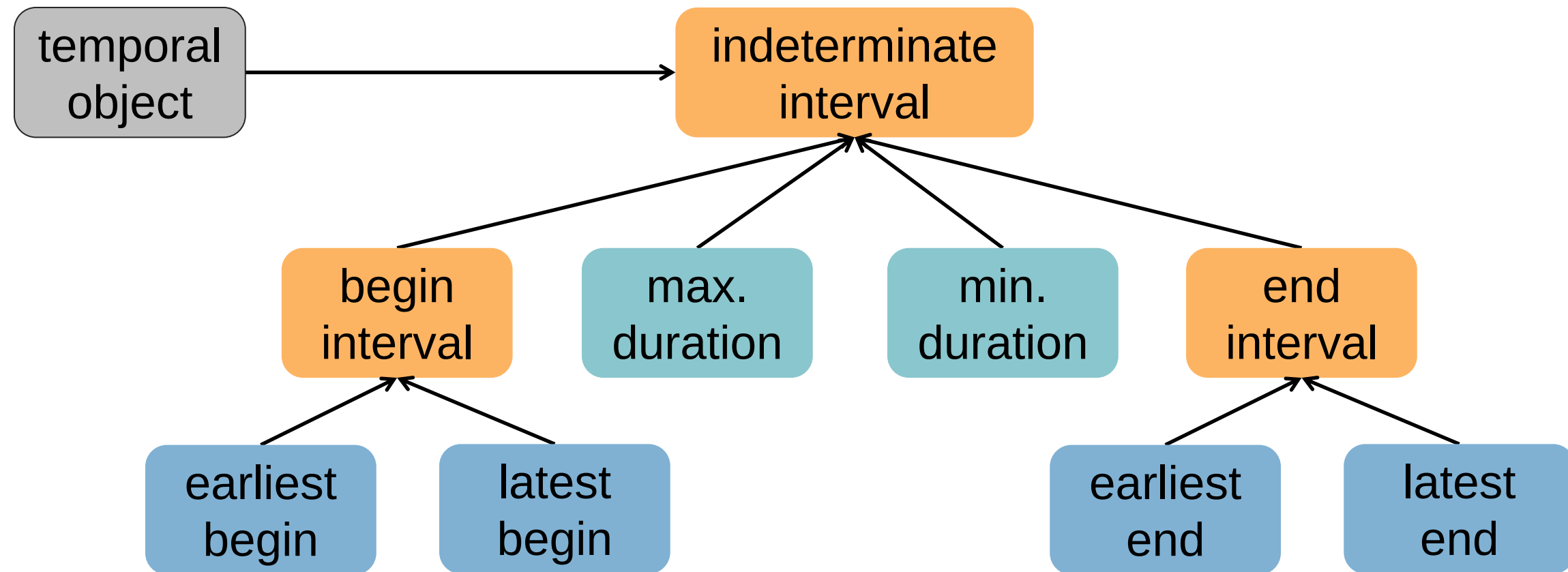
interval index



Challenging Aspect: Temporal Indeterminacy



Hierarchy of Primitives for Indeterminacy



Library Components

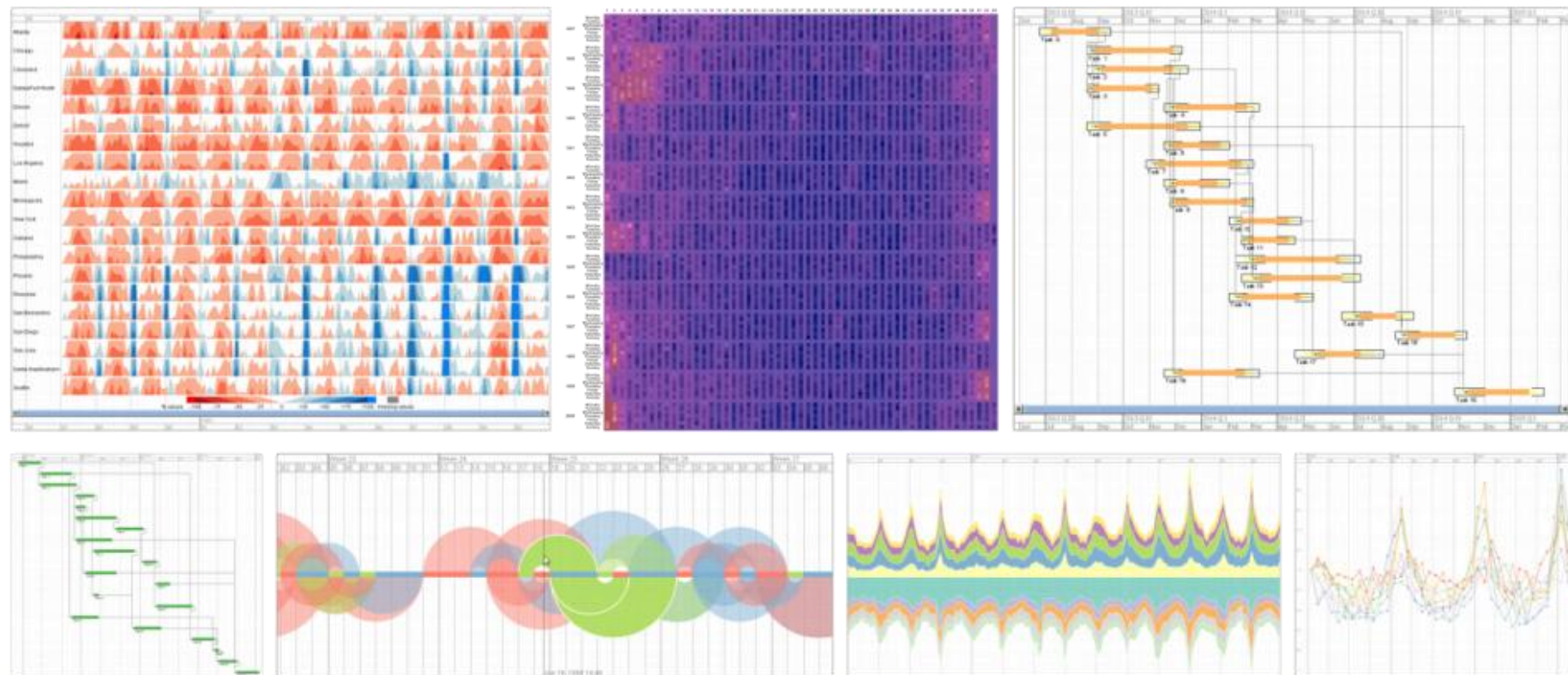
calendar
operations

data
structures

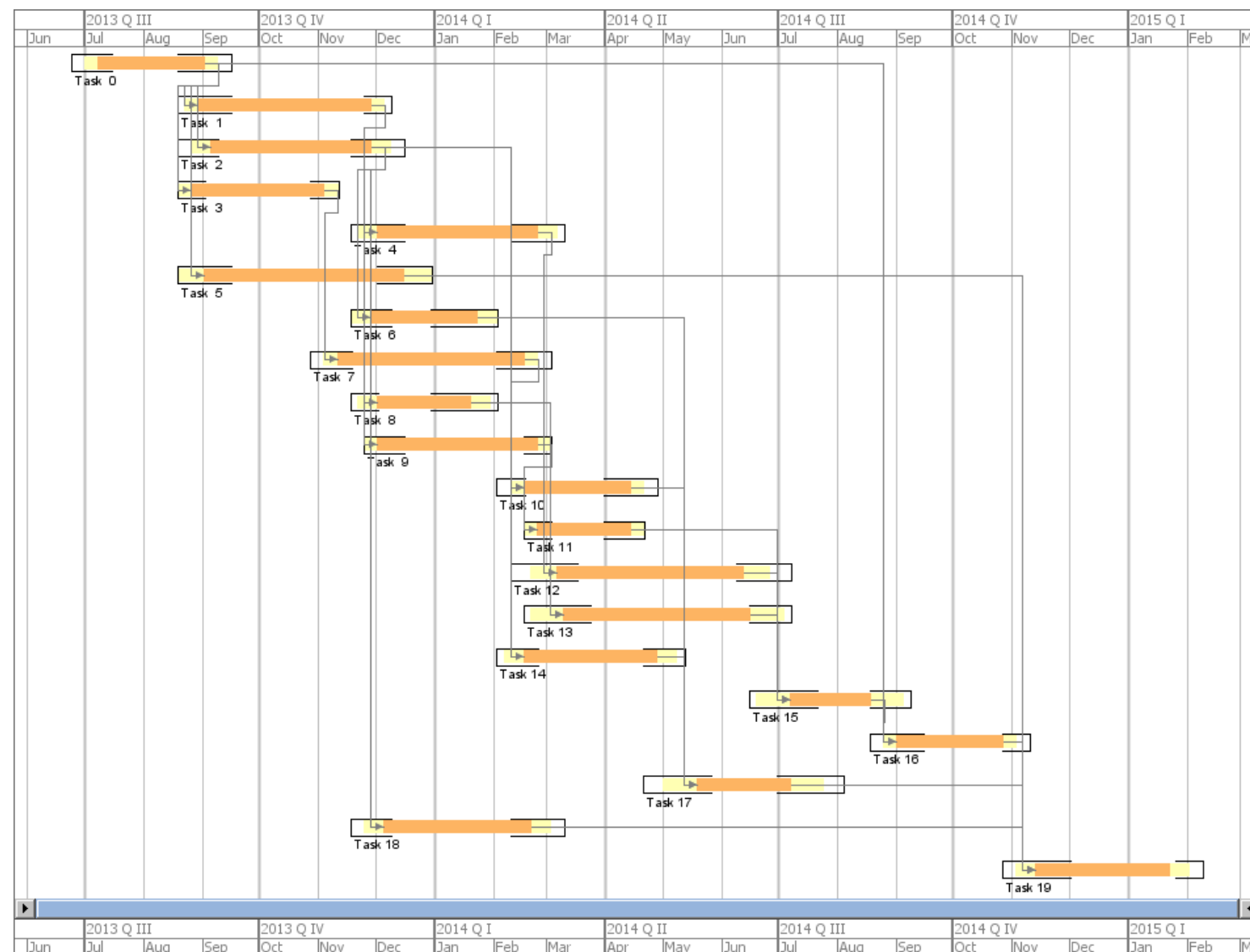
data
transformations

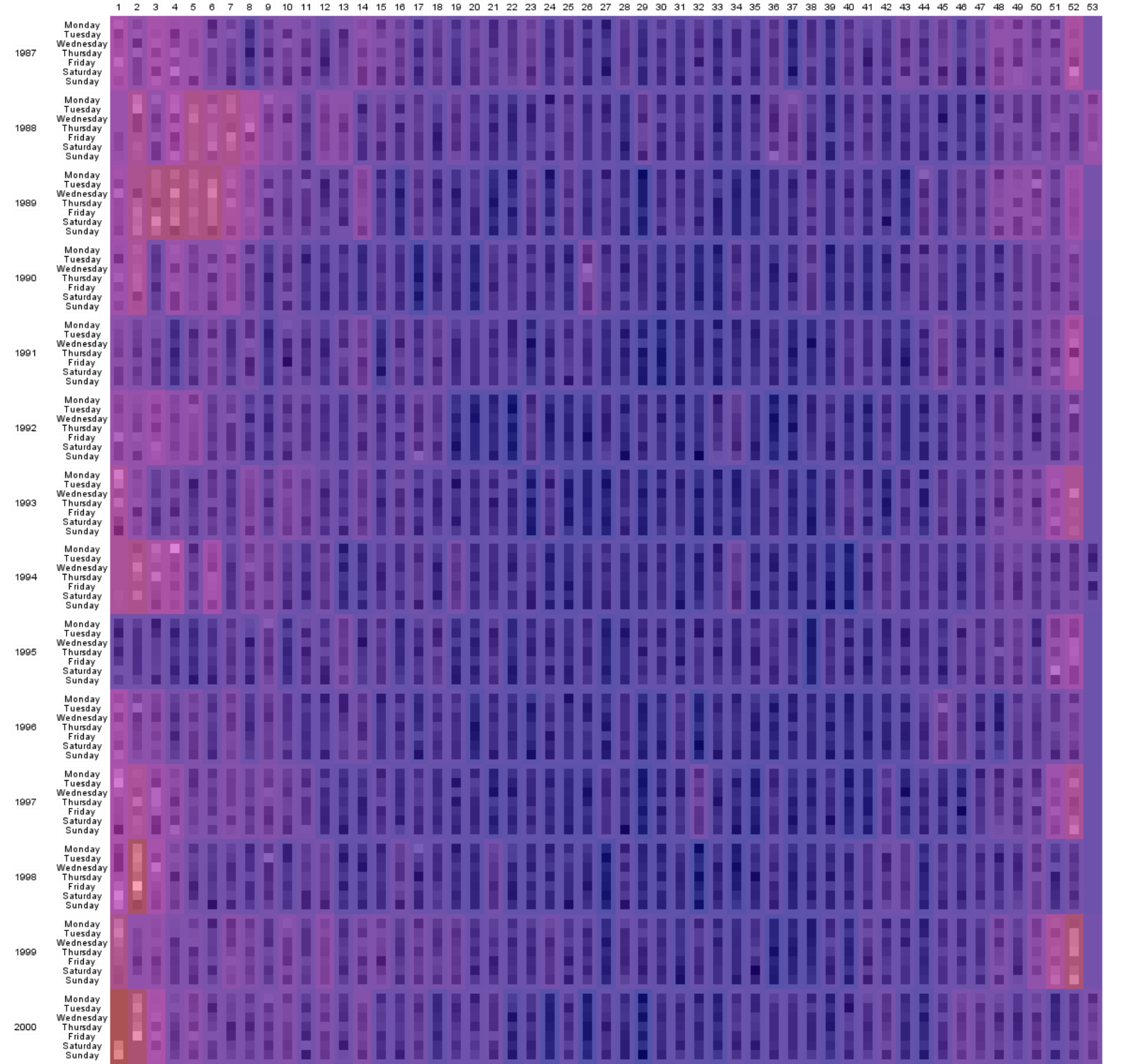
visualization
& interaction

Visual Analytics Library

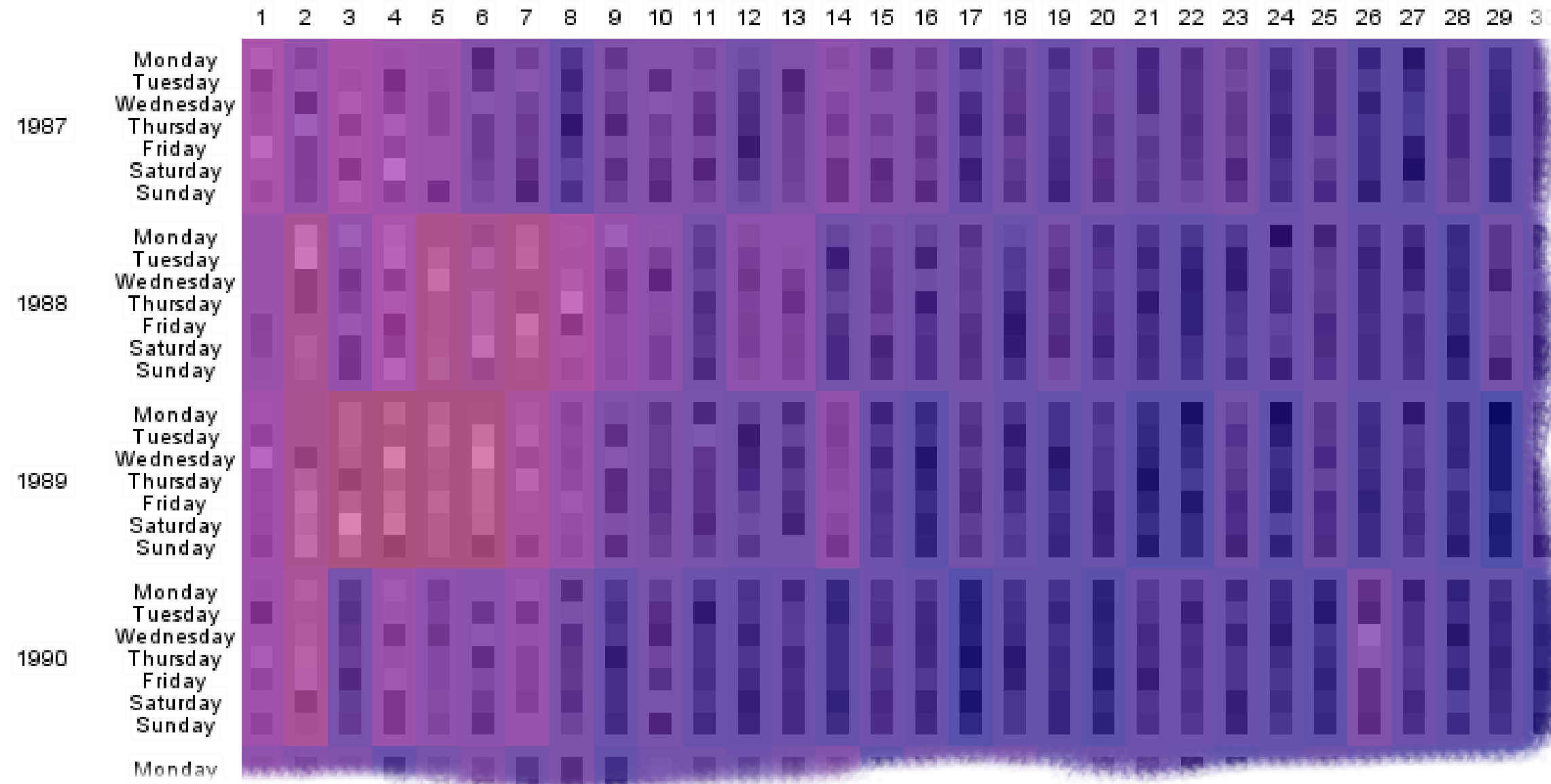


Application Example: PlanningLines



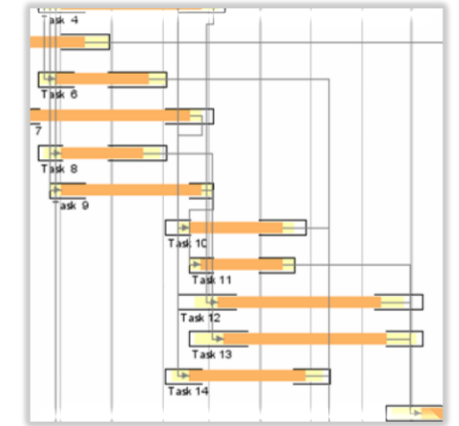
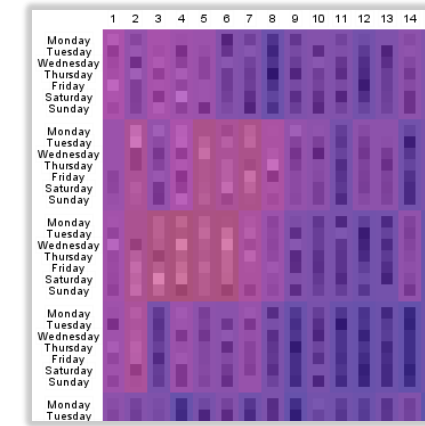
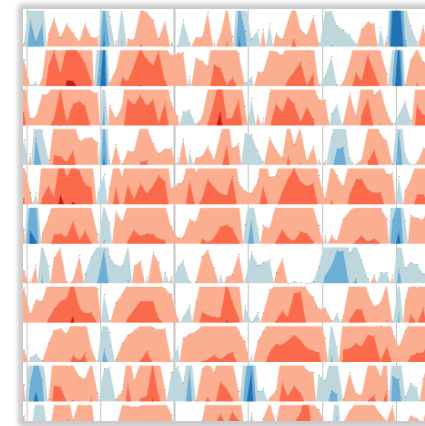


Application Example: GROOVE



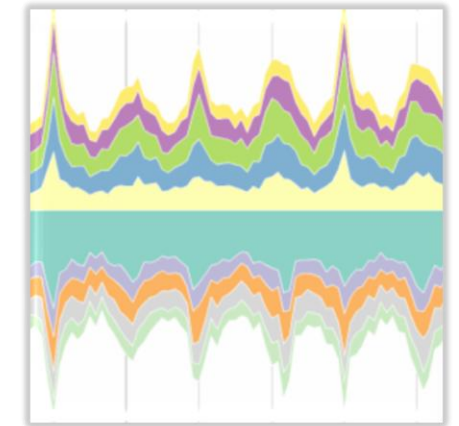
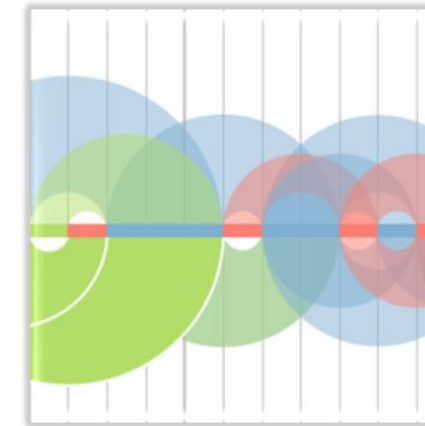
Evaluation

application examples
challenging VA methods
different data characteristics



long-term developer studies
in student & research project

- TiMoVA
- temporal pattern discovery [C&G, 2014]
- high-school graduation project



Evaluation Results

expressiveness

demonstrate applicability in a range of challenging projects

common data structure

no adaptation of the data structure needed

developer accessibility

tested with university and high-school students

runtime efficiency

examples run smoothly with thousands of temporal objects

Future Work

- extend with new transformations and visualization methods
- integrate with data sources
- add freely configurable calendars
- support branching time
- extend for spatial & spatio-temporal data

Future Work

TimeBench source code published at GitHub
<https://github.com/ieg-vienna/TimeBench>

community building

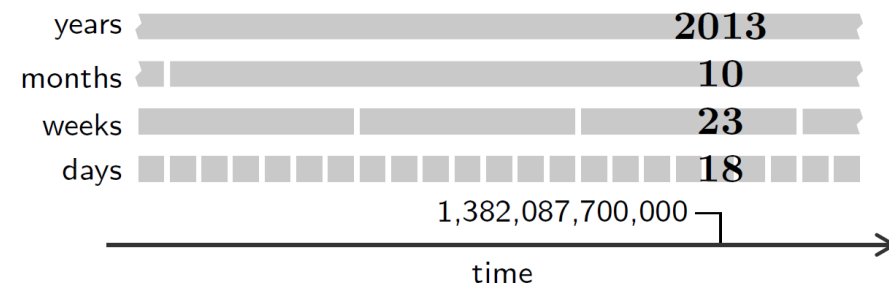
- promotion
- tutorials
- pull requests



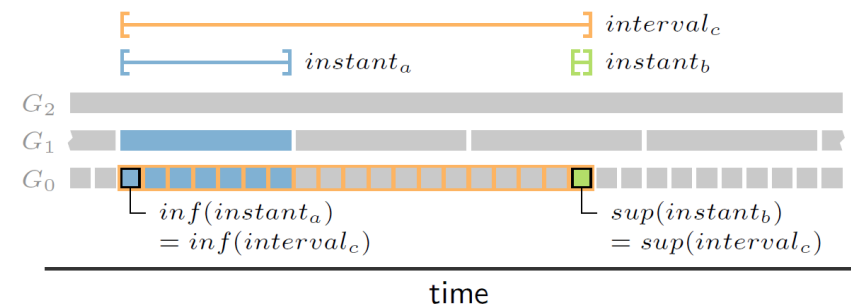
TimeBench.org

A Software Library for
Visual Analytics of Time-Oriented Data

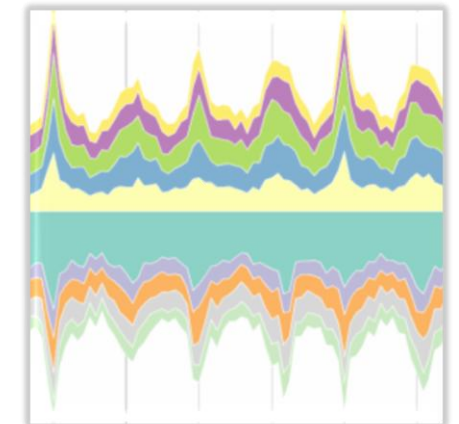
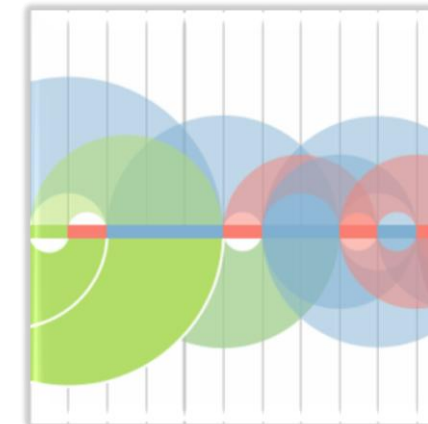
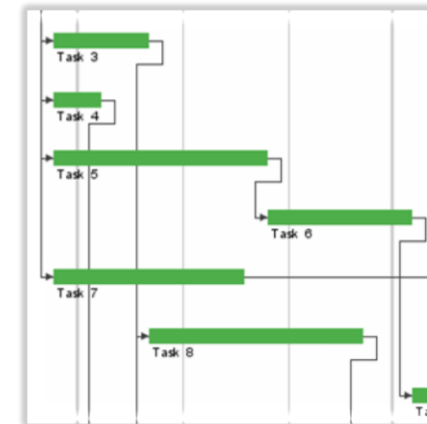
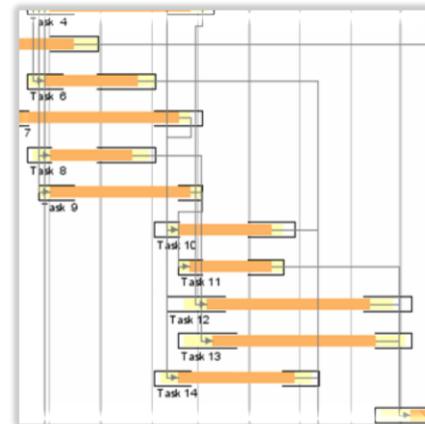
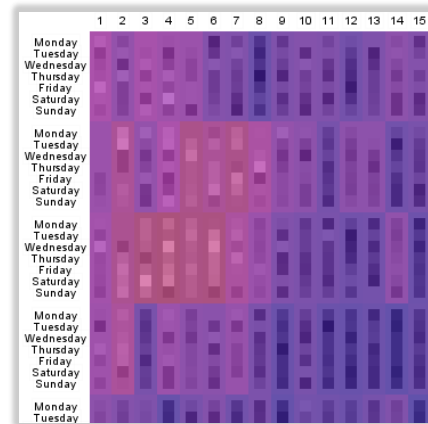
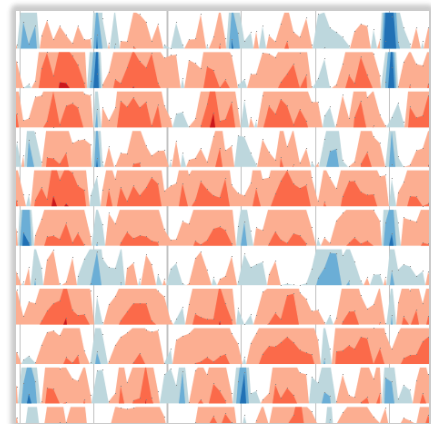
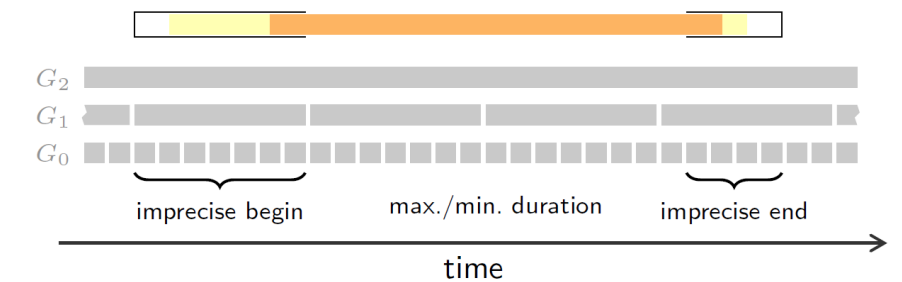
multiple granularities & cycles



different time primitives



temporal indeterminacy





A Software Library for
Visual Analytics of Time-Oriented Data

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