SOWL: A Framework for Handling Spatio-Temporal Information in OWL 2.0

Sotiris Batsakis
Euripides G.M. Petrakis

Technical University Of Crete
Intelligent Systems Laboratory

Introduction

- SOWL
  - Spatiotemporal model in OWL
  - Representation of quantitative and qualitative information
  - Spatiotemporal reasoning using SWRL
  - Preliminary version SWAP'10

Motivation

- SOWL addresses limitations of existing spatiotemporal representation approaches
  - Support of qualitative information in addition to quantitative
- Reasoning Support over quantitative and qualitative information
- Query support KES'2011

Temporal Representation in Semantic Web (1/2)

- Temporal RDF
  - Labeling properties with temporal information
  - Quantitative temporal information is supported
  - Extends standard RDF
- Versioning
  - Different version of ontology whenever a change occurs
  - Data redundancy, reasoning

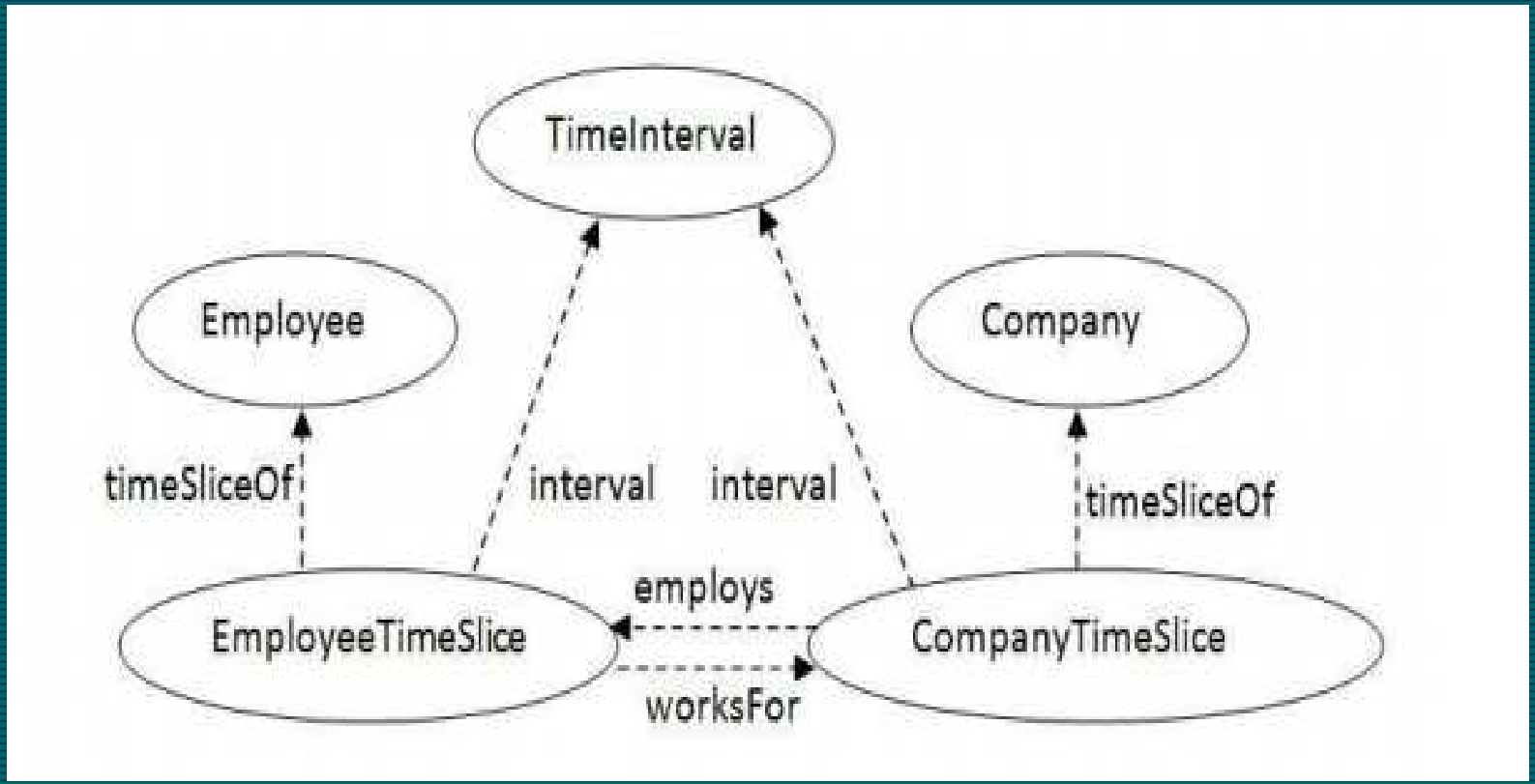
Temporal Representation in Semantic Web (2/2)

- Reification
  - Represents temporal relations between objects and a time interval as objects themselves
  - General purpose technique
  - Data redundancy
- Named Graphs
  - Separate named graph for each interval
  - No reasoning support

4-D fluents

- Static properties attached to objects
- Dynamic Properties attached to time slices of objects
  - A time slice object is created each time a fluent property changes it’s value
- Time slices
  - Attached to specific static objects
  - Connect to time intervals

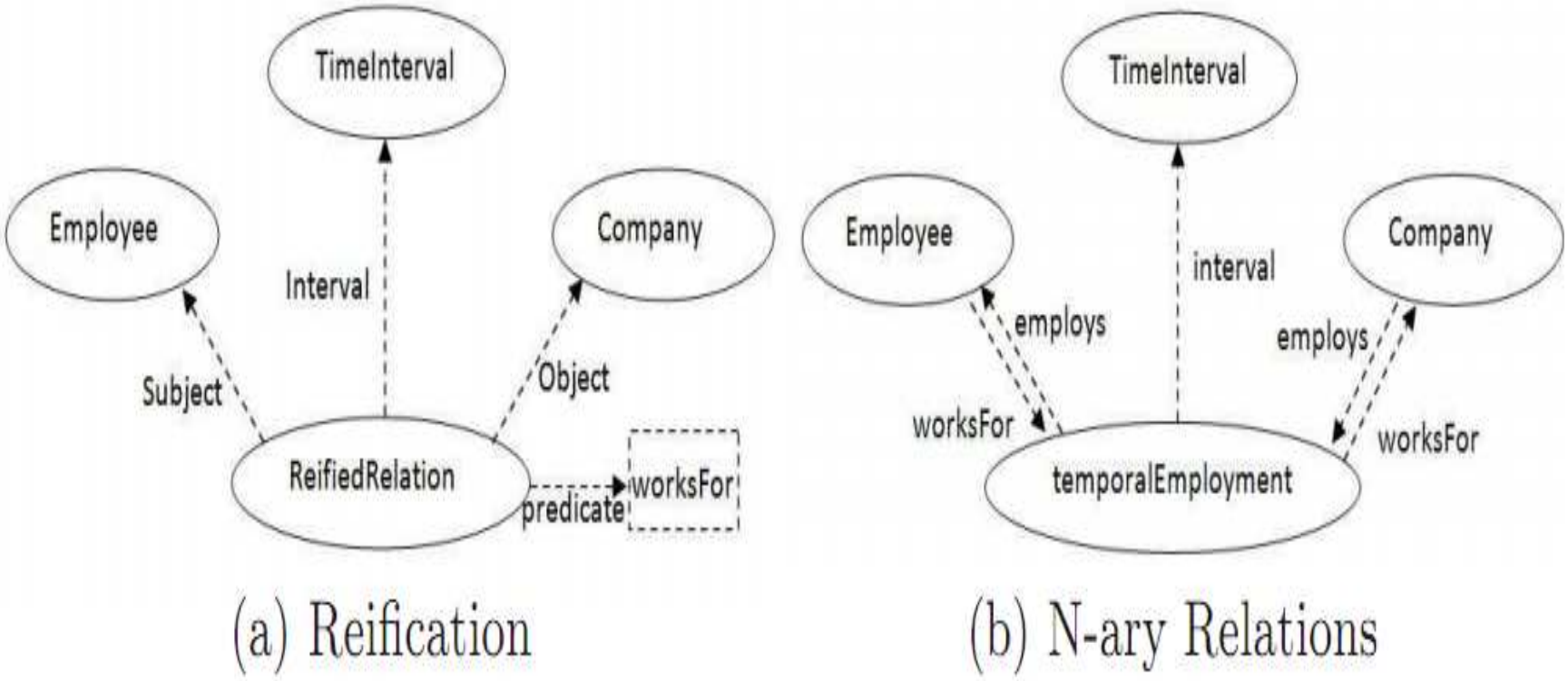
4-D fluents example



N-ary relations

- Static properties attached to objects
- Dynamic Properties attached to reified objects representing events
  - Dynamic properties are represented as properties and not as objects of properties as in reification
- Event objects
  - Attached to specific static objects
  - Connect to time intervals

N-ary example



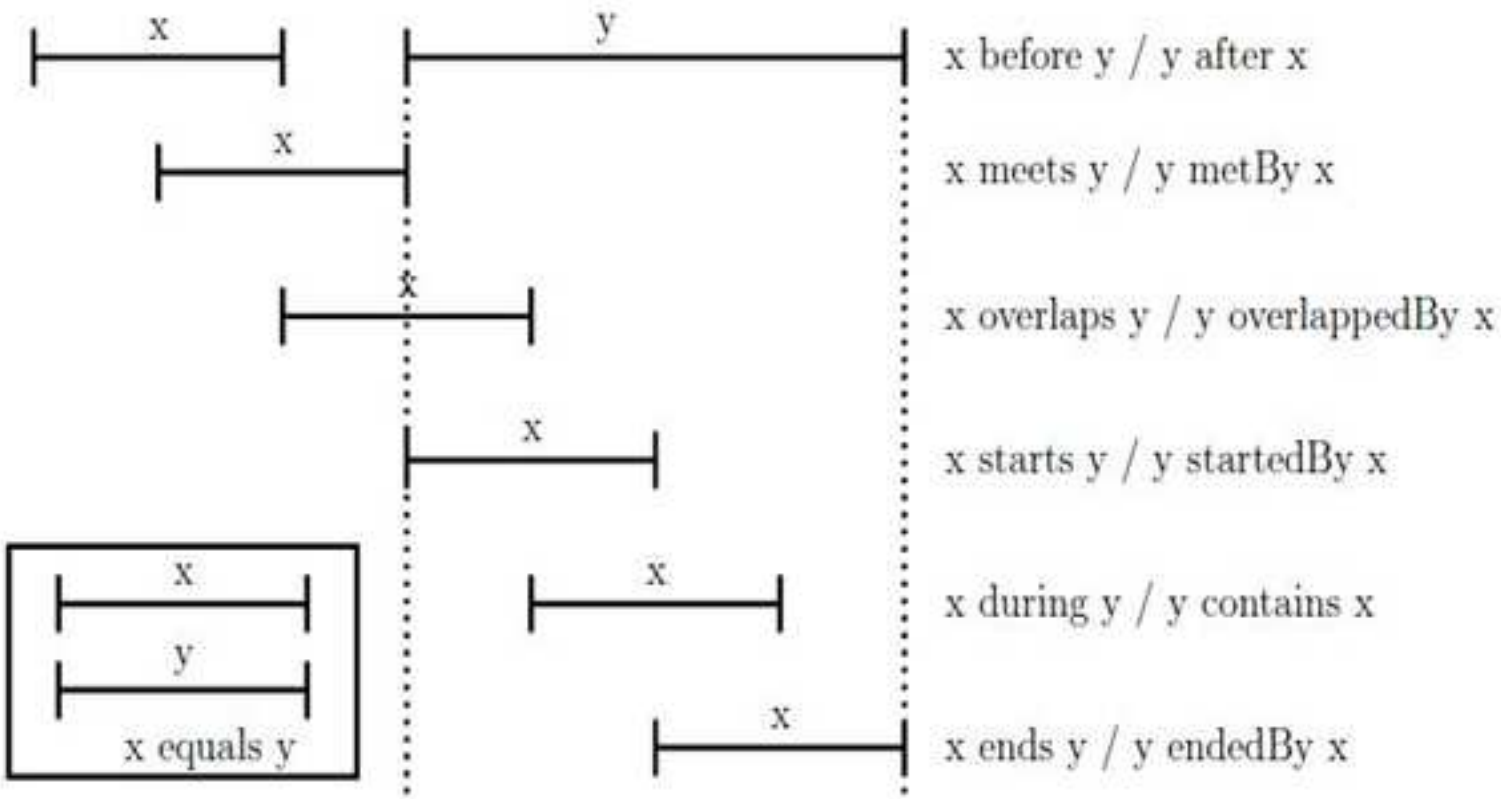
4-D fluent/N-ary comments

- Advantages
  - Changes affect only related objects not entire ontology
  - OWL compatible
  - Reasoning mechanisms and semantics of OWL are supported
- Disadvantages
  - Data redundancy

Extending 4-D fluents/N-ary

- Qualitative Allen Relations (e.g., Before, After) are supported
- Qualitative relations connect temporal intervals
- Interval with unknown endpoints are also represented
- Representation of Spatial information

Allen Temporal Relations



Motivation for Reasoning

- Asserting qualitative relations over temporal intervals or spatial locations with unknown endpoint(s) isn't adequate
  - Assertions combined with spatiotemporal semantics yield inferred relations
  - Assertions may be inconsistent

Qualitative Spatiotemporal Reasoning

- Reasoning over Qualitative Spatiotemporal Relations (e.g., Allen Relations) is intractable if all relations are supported
- Possible Solutions:
  - Using algorithms with exponential worst case complexity
  - Using polynomial approximation algorithms
  - Restrict supported relations to sets decided by polynomial algorithms such as Path Consistency

Temporal Reasoning(1/2)

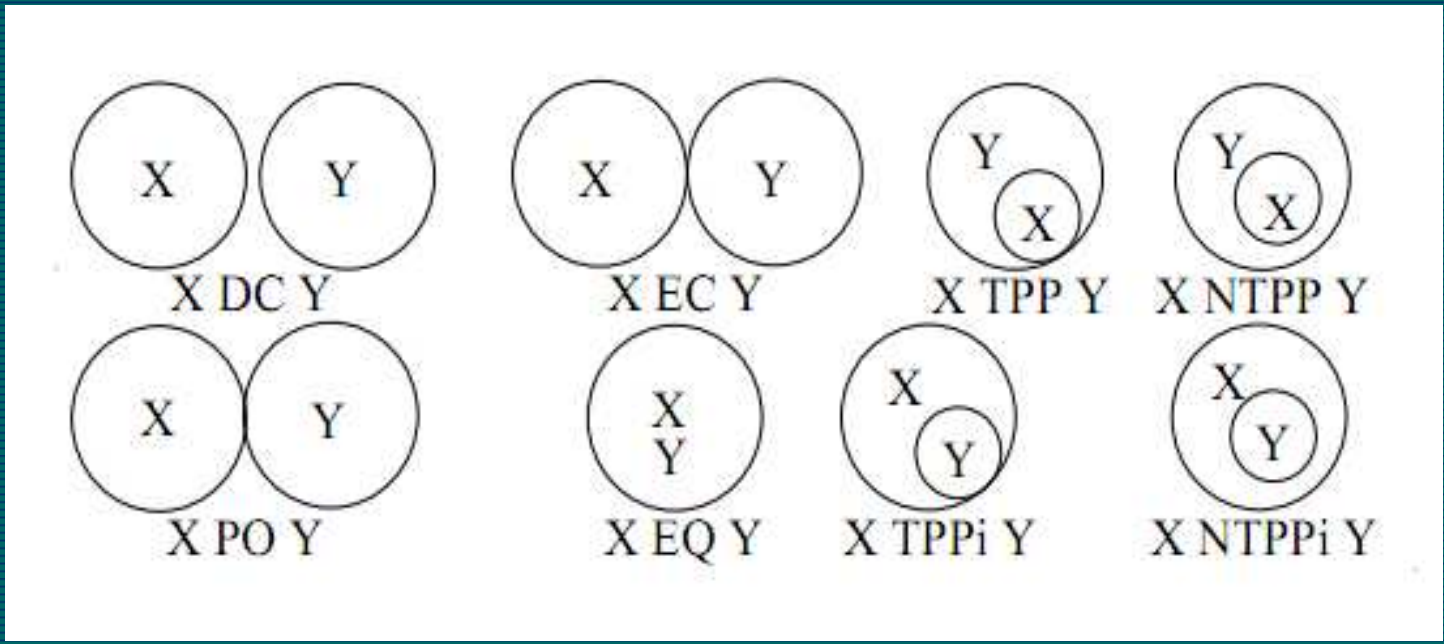
- Based on Path Consistency
  - Composing and intersecting relations until:
    - Fixed point is reached (no additional inferences can be made)
    - Empty relation is yielded implying inconsistent assertions
  - Path Consistency is tractable, sound and complete for specific sets of temporal relations
- Implementation in SWRL

Temporal Reasoning (2/2)

- Compositions and intersections of relations are defined
- Disjunctions of relations are represented if they belong to the supported tractable set
- Example rules:
  - During(x,y) AND Meets(y,z)➔ Before(x,z)
  - (Before(x,y) OR Meets(x,y))
    AND Meets(x,y)➔Meets(x,y)

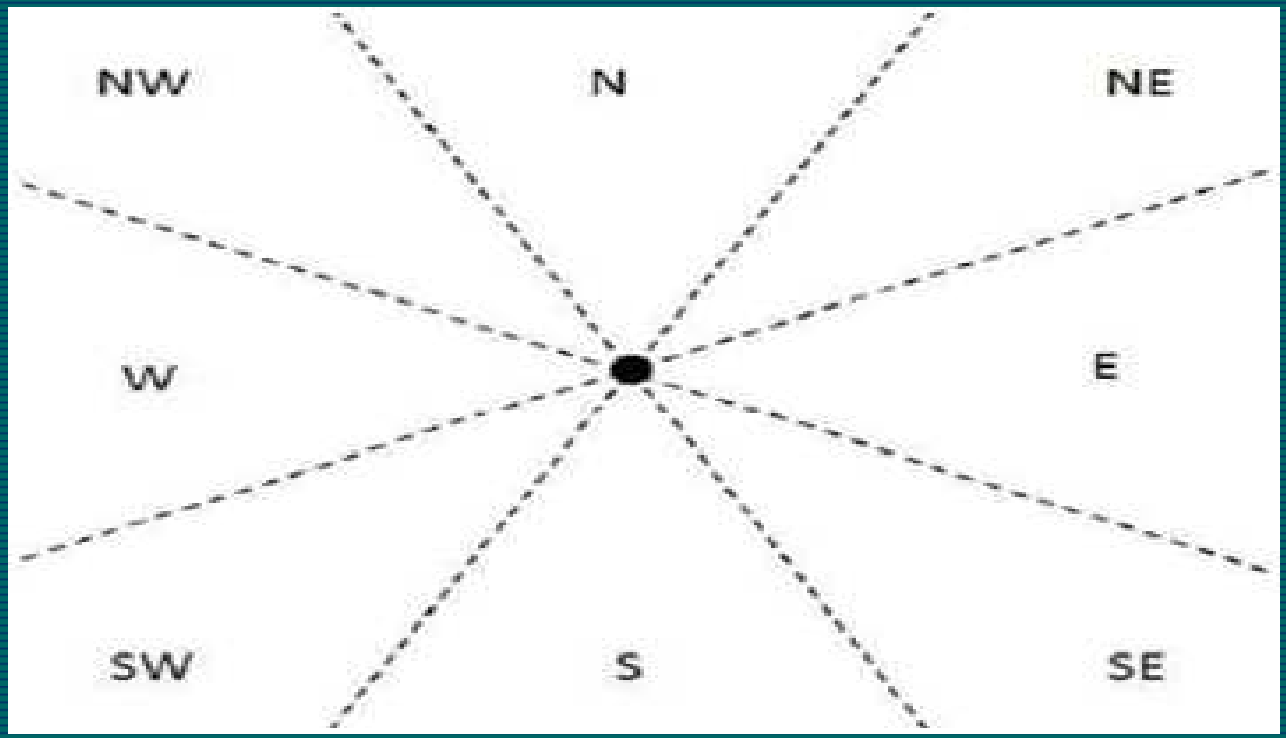
Spatial Representation(1/2)

- Topologic RCC-8 Relations



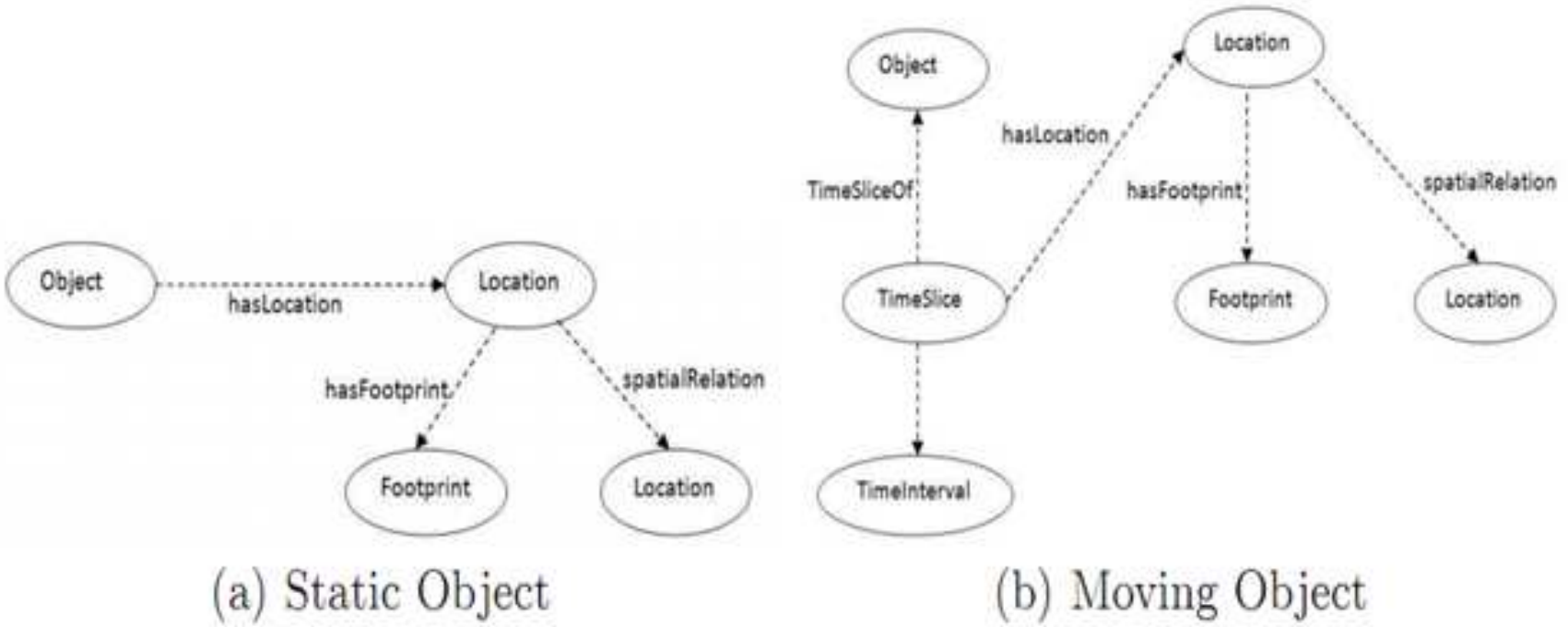
Spatial Representation(2/2)

- Cone-based directional relations



Combining Temporal and Spatial properties

- 4D-fluents example



Spatial Reasoning(1/2)

- Extracts relations from
  - Existing qualitative relations
  - Extract qualitative relations from quantitative data (i.e., coordinates) using an external application
- Apply path consistency on topologic and directional relations

Spatial Reasoning(2/2)

- Limits to tractable sets of spatial relations
- Reasoning is polynomial with respect to the number of spatial entities
- Example SWRL rules:
  - NTPP(x,y) AND DC(y,z)➔DC(x,z)
  - SOUTH(x,y) AND SOUTH(y,z)
    ➔ SOUTH(x,z)

Conclusion

- SOWL is an approach for representing spatiotemporal information in OWL ontologies
- Supports both, temporal and spatial reasoning over qualitative relations

Future Work

- SPARQL based query language KES'2011
- Optimizations for large scale applications

Thank You

- Questions?