Towards a Taxonomy of Syntactic and Semantic Matching Mechanisms for Aspect-oriented Modeling

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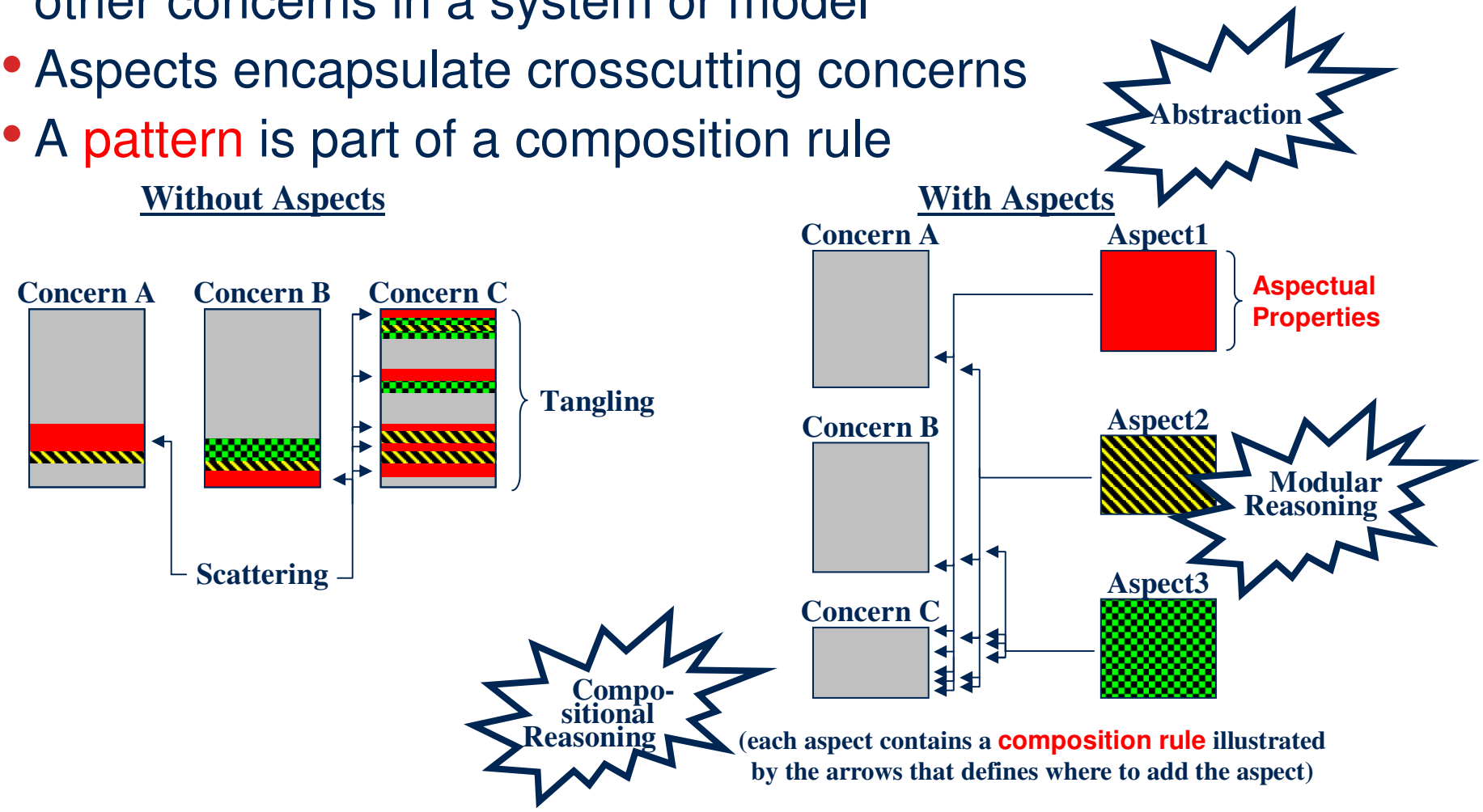
Background: Aspect-oriented Modeling (AOM)

- Aspects address the problem of one concern crosscutting other concerns in a system or model
- Aspects encapsulate crosscutting concerns
- A pattern is part of a composition rule



Background: Aspect-oriented URN (AoURN)

- Aspect-oriented User Requirements Notation
  - Extends the abstract syntax, the concrete syntax, and the semantics of URN (ITU-T Z.150 series) with aspect-oriented concepts
  - Unifies goal-oriented, scenario-based, and aspect-oriented concepts in a scalable framework
    - Behavioral/structural properties of a concern are modeled with scenarios
    - Reasons/trade-offs for a concern are modeled with goal models
  - Requires almost no changes to the familiar URN notation (syntax remains virtually the same but the semantics are extended)
  - Typically, AoURN models each use case, each stakeholder's goals, and each non-functional requirement/quality as a concern (→ separation of concerns)
  - Exhaustive composition of aspects (expressed with URN itself)
  - Aspectual properties and patterns are defined separately as much as possible


Motivation

- Typically, pattern matching is based solely on syntactic elements
- Exploit semantic matching to make aspects more generic and more robust to changes and different modeling styles

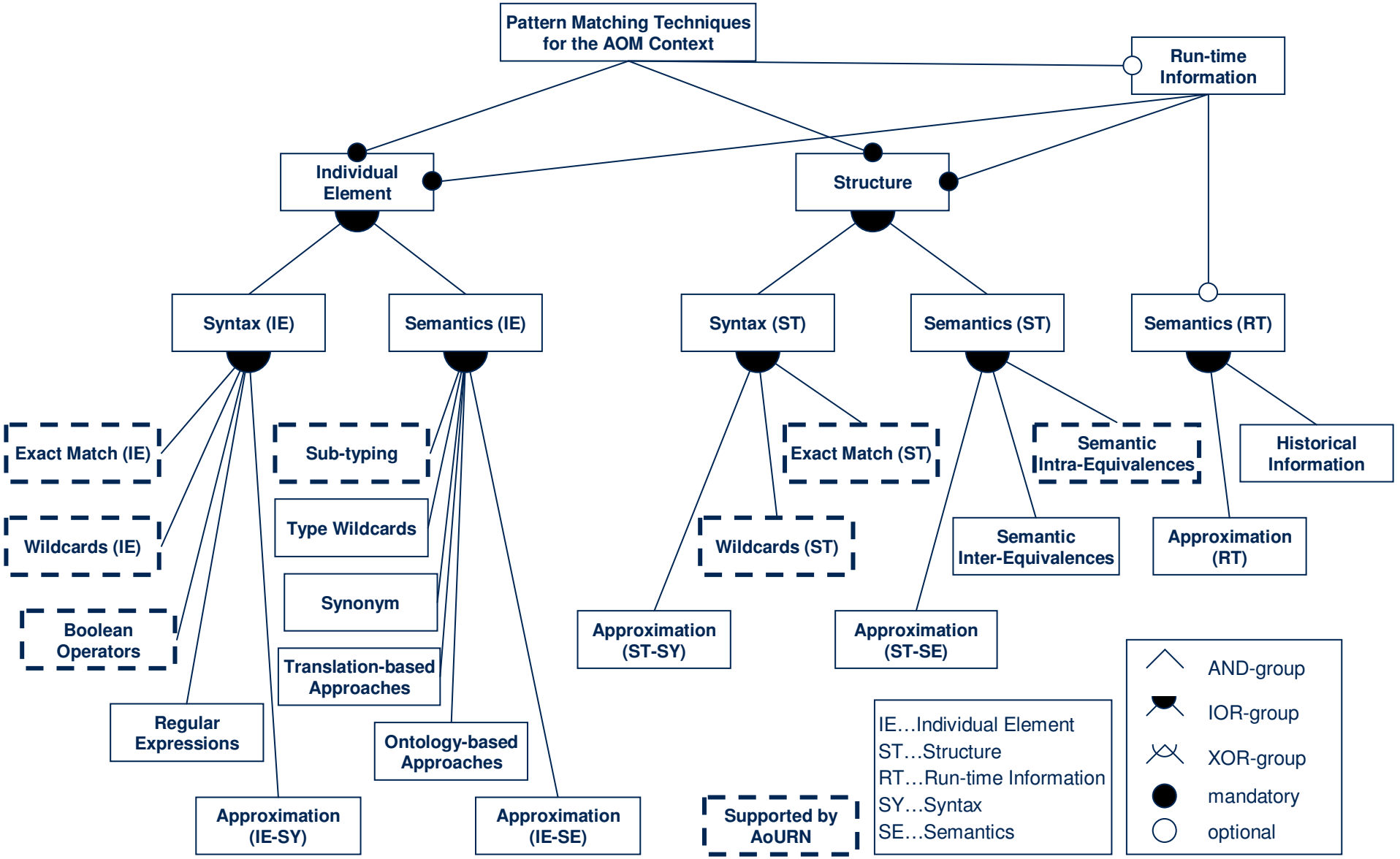
- ➔ Classify matching mechanisms based on how syntactic or semantic information is used during the matching process
  - Define levels of sophistication for matching mechanisms from simple syntactic approaches to complex semantic approaches

- The database research community has been investigating schema matching techniques for years
- ➔ Are they applicable in the AOM context?


Sample Techniques from the Database Community

- String-based Techniques
  - Prefix (e.g., int and integer); Suffix (e.g., phone and telephone)
  - Edit distance (e.g., distance among NKN and Nikon is 2/5)
  - N-gram (distance between nkon and nikon is 1/3)
- Language-based Techniques
  - Tokenization (e.g., Hands-Free Kits → <hands, free, kits>)
  - Lemmatization (e.g., Kits → kit)
  - Elimination (e.g., The Kits → Kits)
- Linguistic Resources (e.g., thesauri)
  - Synonyms (Car vs. Automobile)
  - Hyponyms / Hypernyms (Digital Camera vs. Camera)
- Measures to evaluate quality & effectiveness of matchers
  - *F-Measure, Overall (*based on the *Precision* and *Recall* functions)


Taxonomy of Pattern Matching Techniques for AOM



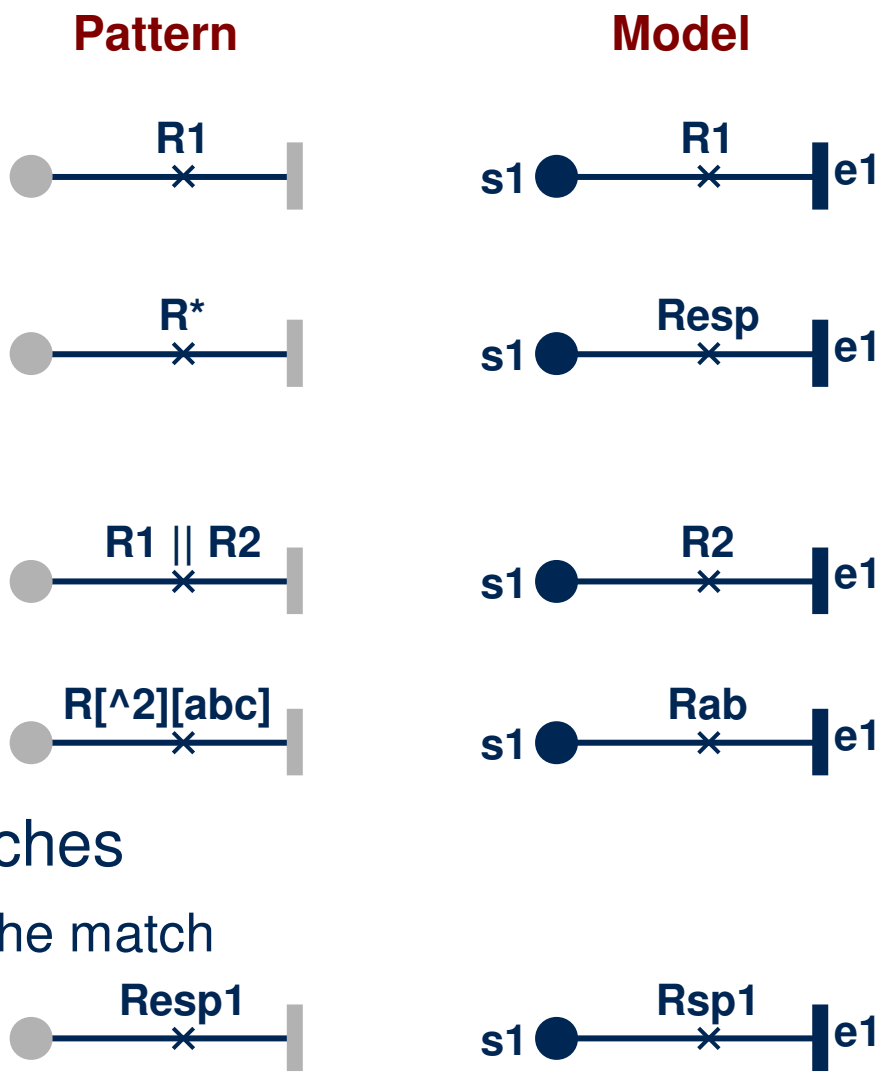
Syntax-Based Matching of Individual Elements

Exact Match

Wildcards

Boolean Operators

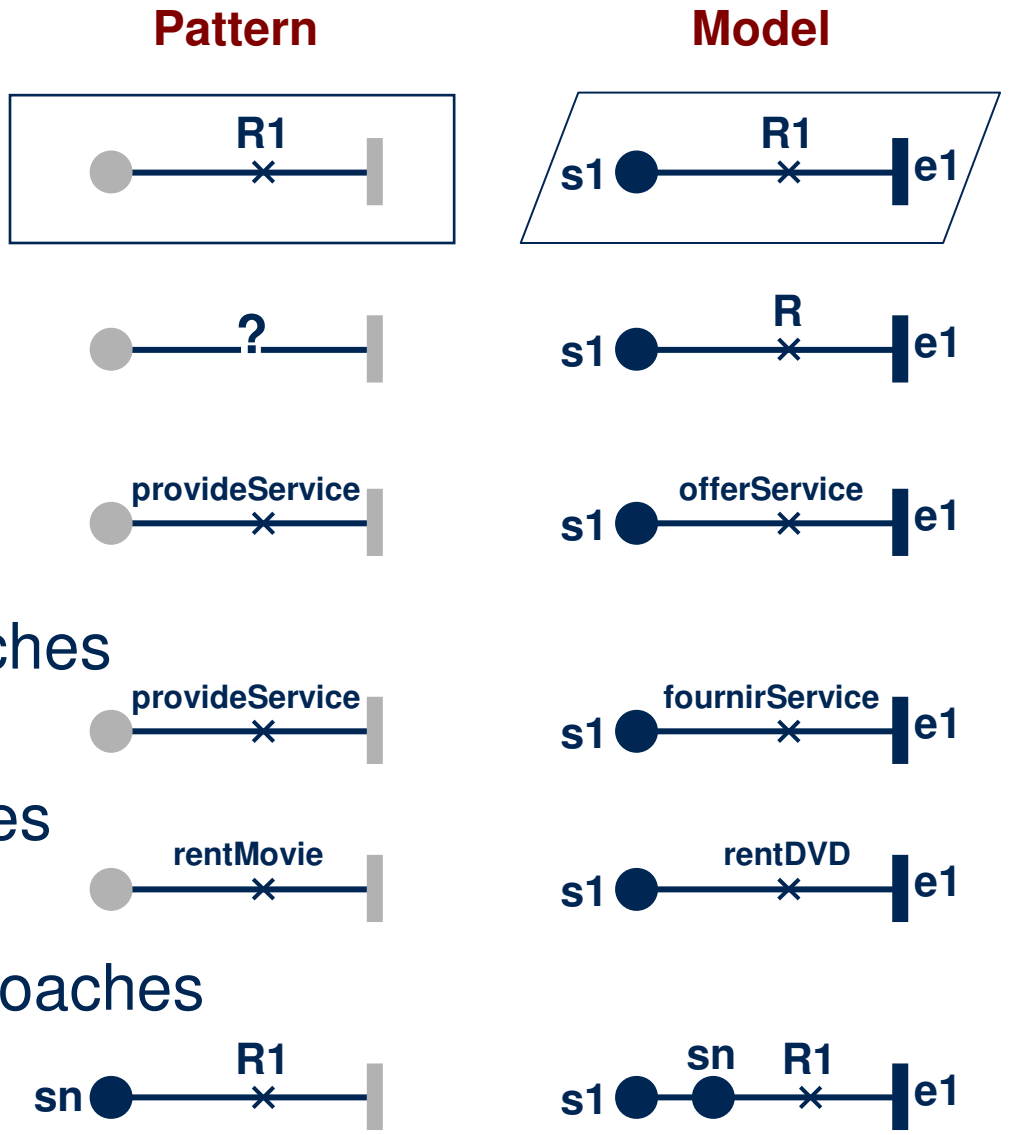
- Regular Expressions
- Approximation-based Approaches
  - Tolerant of small differences in the match



Semantics-Based Matching of Individual Elements

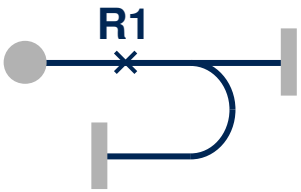
Sub-typing

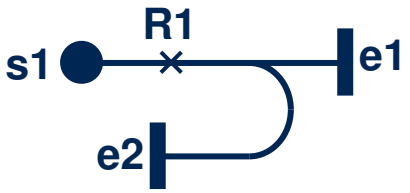
- Type Wildcards
- Synonym
- Translation-based Approaches
- Ontology-based Approaches
- Approximation-based Approaches



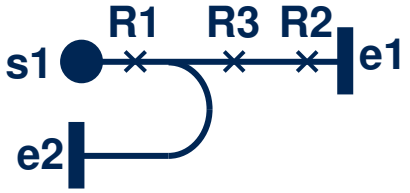
Syntax-Based Matching of Structure

Exact Match

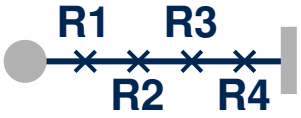




Wildcards

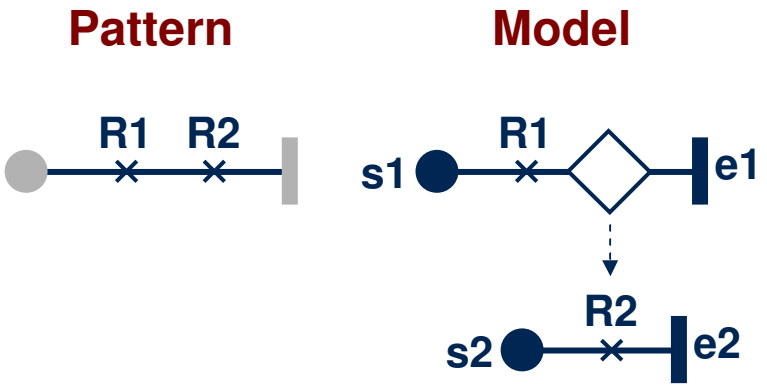


- Approximation-based Approaches



Semantics-Based Matching of Structure

- Semantic Intra-Equivalences
  - Exploits semantic equivalences of a single language to improve the matching results



- Semantic Inter-Equivalences
  - Exploits semantic equivalence across modeling language barriers

- Approximation-based Approaches
  - Allow patterns to be matched that could but not necessarily have to match

Matching of Run-time Information

- May make use of all syntax-based and semantics-based techniques for individual elements and structure
  - Supports in-context, dynamic aspect composition
  - E.g., patterns may include results of trade-off analyses for AoURN's goal models
- Historical Information
  - E.g., patterns may consider trends in the last five results of the AoURN trade-off analyses
- Approximation-based Approaches
  - E.g., patterns may determine a value range for a successful match


Conclusion and Future Work

- Presented a first attempt at establishing a taxonomy for pattern matching techniques in the AOM context
- Approximation-based techniques that have been extensively used in the database research community should be investigated more thoroughly in the AOM context
- Future Work
  - Validate our taxonomy by classifying further AOM techniques with it
  - Implement some of the new techniques in the AoURN tool
  - Contributions from the model comparison and merging research area could expand and consolidate our taxonomy