

Megamodel-driven Traceability Recovery & Exploration of Correspondence & Conformance Links

Bachelorarbeit

zur Erlangung des Grades eines Bachelor of Science
im Studiengang Informatik

vorgelegt von

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Koblenz, im Juni 2017

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Zusammenfassung

TBD.

Abstract

TBD.

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Introduction

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Chapter 2

Related Work

TBD.

Chapter 3

Background

This section summarizes the necessary background topics of the thesis. Each topic is introduced independently, interrelation is done during synthesis of hypotheses for this thesis in chapter 4.

3.1 Relations

This section introduces the necessary aspects of mathematical relations for this thesis. The concept of relations is a generalization of semantic dependencies between two or more mathematical objects. This section is based on [1].

Relations are based on set-theory. We also introduce the necessary constructs of set-theory in order to clarify terminology and notation. A set is a collection of well distinguishable mathematical objects. Objects in a set are called elements of the set. A set does not contain two or more identical elements. The notation $x \in X$ denotes that x is an element of the set X . The symbol \emptyset denotes the *empty set*, which contains no elements. The symbol Ω denotes the universal set, which contains all elements.

Definition 1 (Inclusion) *Let X and Y be a sets. Y includes X if and only if:*

$$X \subset Y :\Leftrightarrow \forall x[x \in X \Rightarrow x \in Y] \quad (3.1)$$

Then X is called subset of Y and Y is called superset of X . For an arbitrary set $Z \neq \emptyset$, the statement $\emptyset \subset Z$ is always true, respectively $Z \subset \emptyset$ is always false.

Definition 2 (Union) Let X and Y be a sets.

$$X \cup Y := \{x | x \in X \vee x \in Y\} \quad (3.2)$$

$X \cup Y$ is called union of X and Y .

Definition 3 (Intersection) Let X and Y be a sets.

$$X \cap Y := \{x | x \in X \wedge x \in Y\} \quad (3.3)$$

$X \cap Y$ is called intersection of X and Y .

Definition 4 (Power-Set) Let X be a set, then the power-set of X is defined as:

$$\mathcal{P}(X) := \{Y | Y \subset X\} \quad (3.4)$$

The definition of inclusion provides an order for power-sets. So we may compare two sets A and B in the sense of *smaller* and *larger*, i.e.:

$$A \text{ is smaller than } B \Leftrightarrow A \subset B \quad (3.5)$$

$$A \text{ is larger than } B \Leftrightarrow B \subset A \quad (3.6)$$

$$A \text{ is the smallest subset of } B \Leftrightarrow \forall C \in \mathcal{P}(B) : A \subset C \quad (3.7)$$

$$A \text{ is the largest subset of } B \Leftrightarrow \forall C \in \mathcal{P}(B) : C \subset A \quad (3.8)$$

Definition 5 (Upper & Lower Bound) Let Ω be a universe, $X \in \mathcal{P}(\Omega)$ be a set in the universe and $A \subset \mathcal{P}(U)$, $A \neq \emptyset$, non-empty subsets in the universe.

$$X \text{ is an upper bound for } A \Leftrightarrow \forall Y \in A : Y \subset X \quad (3.9)$$

$$X \text{ is a lower bound for } A \Leftrightarrow \forall Y \in A : X \subset Y \quad (3.10)$$

We also define:

$$\mathbf{U}_A := \{U \in \mathcal{P}(\Omega) | \forall Y \in A : Y \subset U\} \quad (3.11)$$

$$\mathbf{L}_A := \{L \in \mathcal{P}(\Omega) | \forall Y \in A : L \subset Y\} \quad (3.12)$$

as sets of all upper/lower bounds for A .

Because our definition of upper and lower bounds is based on power-sets, existence is guaranteed: Given an arbitrary set S , the S and \emptyset are always elements of $\mathcal{P}(S)$. For each element Y of a non-empty selection $A \subset \mathcal{P}(S)$ of the power-set, $Y \subset S$ and $\emptyset \subset Y$ holds. So S is an upper and \emptyset is a lower bound for A .

Definition 6 (Supremum & Infimum) Let Ω be a universe, $X \in \mathcal{P}(\Omega)$ be sets in the universe and $A \subset \mathcal{P}(\Omega)$, $A \neq \emptyset$ a non-empty selection of sets in the universe. If

$$X = \sup A := \bigcup_{Y \in A} Y : \Leftrightarrow X \in \mathbf{U}_A \wedge \forall U \in \mathbf{U}_A : X \subset U \quad (3.13)$$

$$X = \inf A := \bigcap_{Y \in A} Y : \Leftrightarrow X \in \mathbf{L}_A \wedge \forall L \in \mathbf{L}_A : L \subset X \quad (3.14)$$

then X is called supremum/infimum for A .

Existence for supremum and infimum is guaranteed, because upper and lower bounds exist as shown above. Thus, for any non-empty selection $A \subset \mathcal{P}(S)$ of a power-set, \mathbf{U}_A and \mathbf{L}_A are not empty. So we need to proof, that $X = \bigcup_{Y \in A} Y$ respectively $X = \bigcap_{Y \in A} Y$ are in fact the smallest upper and the largest lower bound. Or in other words: Is there another bound $X' \in \mathbf{U}_A$ or $X' \in \mathbf{L}_A$ with $X' \neq X$ so that $X' \subset X$ respectively $X \subset X'$ holds?

1. Supremum: We assume $X' \in \mathbf{U}_A$ with $X' \neq X$ and $X' \subset X$ for $X = \bigcup_{Y \in A} Y$ exists, then an element $x \in X$ exists, which is not element of X' . Because X is the union of all sets in selection A , x must be element of at least one of its sets. However, then X' cannot include sets containing x . Thus, X' cannot be an upper bound for A and $X = \sup A$.
2. Infimum: We assume $X' \in \mathbf{L}_A$ with $X' \neq X$ and $X \subset X'$ for $X = \bigcap_{Y \in A} Y$ exists, then an element $x \in X'$ exists, which is not element of X . Because X is the intersection of all sets in selection A , x cannot be element of at least one of its sets. However, then X' must include sets containing x . Thus, X' cannot be a lower bound for A and $X = \inf A$.

Supremum and Infimum are unique for any non-empty selection of sets in a universe and can be obtained by its union respectively its intersection.

Definition 7 (Cartesian Product) Let U be a universe and $X_n \in \mathcal{P}(U)$ sets with $i = 1 \dots n, n \in \mathbb{N}$, then:

$$X_1 \times \dots \times X_n := \{(x_1, \dots, x_n)\} \quad (3.15)$$

is called Cartesian product.

Definition 8 (Relation) A relation is a subset of a Cartesian product:

$$R \subset X_1 \times \dots \times X_n \quad (3.16)$$

The relation of only two sets is called **binary relation**. Instead of writing $(x, y) \in R$ we may also use the shorter notation xRy .

An arbitrary relation $R \subset A \times B$ is called *homogeneous* if $A = B$, otherwise it is called *heterogeneous*. However, an arbitrary relation $R \subset A \times B$ is also homogeneous in the sense of $R \subset A \times B \subset (A \cup B) \times (A \cup B)$.

Definition 9 (Properties of Relations) Let $R \subset A \times A$ and $S \subset A \times B$ be homogeneous or arbitrary relations, they may satisfy one or more of the following properties:

$$\text{bijective} :\Leftrightarrow \forall b \in B \exists ! a \in A : (a, b) \in S \quad (3.17)$$

$$\text{function} :\Leftrightarrow \forall a \in A \exists ! b \in B : (a, b) \in S \quad (3.18)$$

$$\text{reflexive} :\Leftrightarrow \forall a \in A : (a, a) \in R \quad (3.19)$$

$$\text{irreflexive} :\Leftrightarrow \forall a \in A : (a, a) \notin R \quad (3.20)$$

$$\text{transitive} :\Leftrightarrow \forall a, b, c \in A : (a, b) \in R \wedge (b, c) \in R \Rightarrow (a, c) \in R \quad (3.21)$$

$$\text{intransitive} :\Leftrightarrow \forall a, b, c \in A : (a, b) \in R \wedge (b, c) \in R \Rightarrow (a, c) \notin R \quad (3.22)$$

$$\text{symmetric} :\Leftrightarrow \forall a, b \in A : (a, b) \in R \Rightarrow (b, a) \in R \quad (3.23)$$

$$\text{asymmetric} :\Leftrightarrow \forall a, b \in A : (a, b) \in R \Rightarrow (b, a) \notin R \quad (3.24)$$

$$\text{antisymmetric} :\Leftrightarrow \forall a, b \in A : (a, b) \in R \wedge (b, a) \in R \Rightarrow a = b \quad (3.25)$$

Definition 10 (Reflexive Closure) Let R be a homogeneous relation.

$$R^\circ := \inf\{C \mid C \supset R \wedge C \text{ reflexive} \} = R \cup I \quad (3.26)$$

Definition 11 (Composition of Binary Relations) The composition $S \circ R \subseteq A \times D$ of two binary relations $R \subseteq A \times B$ and $S \subseteq C \times D$ is defined as:

$$S \circ R := \{(a, d) \in A \times D \mid \exists x \in B \cap C : (a, x) \in R \wedge (x, d) \in S\} \quad (3.27)$$

Definition 12 (Identity Relation) The relation I over a set A with:

$$I := \{(a, b) \in A \times A \mid a = b\} = \{(a, a) \mid a \in A\} \subseteq A \times A \quad (3.28)$$

is called *identity relation*.

The n -th power R^n of a relation R with $n \in \mathbb{N}$ is the product of its composition n -times with itself:

$$R^n = \underbrace{R \circ \dots \circ R}_n \quad (3.29)$$

and can be recursively defined with:

$$R^0 := I \quad (3.30)$$

$$R^n := R \circ R^{n-1} \quad (3.31)$$

3.1.1 Closures

For a relation R over a set A its closure:

- $R \cup I$ is called *reflexive closure*
- $R^+ := R^1 \cup R^2 \cup R^3 \cup \dots$ is called *transitive closure*

$$(a, b) \in R^+ \Leftrightarrow (a, b) \in R^1 \vee (a, b) \in R^2 \vee (a, b) \in R^3 \vee \dots \quad (3.32)$$

$$\Leftrightarrow \exists n \in \mathbb{N} : n \geq 1 \wedge (a, b) \in R^n \quad (3.33)$$

$$\Leftrightarrow \exists n \in \mathbb{N} : n \geq 1 \wedge (a, b) \in R \circ R^{n-1} \quad (3.34)$$

$$\Leftrightarrow \exists n \in \mathbb{N} : n \geq 1 \wedge [\exists x \in A : (a, x) \in R \wedge (x, b) \in R^{n-1}] \quad (3.35)$$

$$\Leftrightarrow \exists n \in \mathbb{N} \exists x \in A : n \geq 1 \wedge (a, x) \in R \wedge (x, b) \in R^{n-1} \quad (3.36)$$

- $R^* := R^+ \cup I$ is called *reflexive-transitive closure*

$$(a, b) \in R^* \Leftrightarrow (a, b) \in R^+ \vee (a, b) \in I \quad (3.37)$$

$$\Leftrightarrow (a, b) \in R^+ \vee a = b \quad (3.38)$$

3.2 Formal Languages & Grammars

3.2.1 Context-Free Languages & Grammars

3.3 Mereology

$$x \text{ partOf } x \quad (\text{Reflexivity}) \quad (3.39)$$

$$x \text{ partOf } y \wedge y \text{ partOf } x \Rightarrow x = y \quad (\text{Antisymmetry}) \quad (3.40)$$

$$x \text{ partOf } y \wedge y \text{ partOf } z \Rightarrow x \text{ partOf } z \quad (\text{Transitivity}) \quad (3.41)$$

TBD.

3.4 Traceability

[2] TBD.

3.4.1 Traceability Relationship

3.4.2 Traceability Link

3.4.3 Traceability Recovery

3.4.4 Traceability Exploration

3.5 Megamodeling

TBD.

3.5.1 MegaL

3.5.1.1 MegaL/Xtext

3.6 Ontologies

TBD.

3.7 Program Analysis

TBD.

3.8 XML Data Binding

TBD.

3.8.1 Java Architecture for XML Binding (JAXB)

3.9 Object Relational Mapping

TBD.

3.9.1 Java Persistence API (JPA)

3.9.2 Hibernate

3.10 Another Tool For Language Recognition (ANTLR)

Chapter 4

Hypotheses

TBD.

4.1 Fragments

4.2 Correspondence

4.3 Conformance

Chapter 5

Methodology

TBD.

5.1 The 101companies Human Resource Management System

Description of the 101companies Human Resource Management System

5.2 Link Proper Part Ratio

The ratio between all proper parts of two artifacts and the proper parts of the same artifacts in a relationship.

$$\pi_{R,A_1,A_2} = \frac{|\{(p_1, p_2) \in R : p_1 \text{ properPartOf } A_1 \wedge p_2 \text{ properPartOf } A_2\}|}{|\{p : p \text{ properPartOf } A_1 \vee p \text{ properPartOf } A_2\}|}$$

Chapter 6

Requirements

TBD.

R1 asdf

R2 asdf

R3 asdf

R4 asdf

Chapter 7

Design

TBD.

Chapter 8

Implementation

TBD.

8.1 Context-Free Grammar Fragmentation

8.2 Name Correspondence Heuristic

Heuristics are quick and "simple" methods for finding good approximate solutions for complex problems. The Name Correspondence Heuristic determines correspondence between artifacts simply by finding similarities of names in those artifacts.

TBD.

Chapter 9

Results

TBD.

Chapter 10

Conclusion

TBD.

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