Do Ontologies Dream of Concepts

Or: Blank Spots in Ontology Engineering

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Science and Fiction

„It was at the Protégé 2021 conference, and Dick Reckard had a license to satisfy concepts.“

„Do Ontologies Dream of Concepts“

A novel by Philipp D. Kick

Science or Fiction?

„Logic Programming and Description Logic go together well“

- ✓ (Protégé Frames and Protégé OWL)
- ✓ KAON2 is an infrastructure for managing OWL-DL, SWRL, and F-Logic ontologies *at the same time*
  - Reasoning based on reduction of SHIQ(D) knowledge bases to disjunctive datalog programs
  - http://kaon2.semanticweb.org/

Science or Fiction?

„Reasoning over a billion statements works“

✓ BigOWLIM successfully passed the threshold of 10^9 statements of OWL/RDF

- Hardware BigOWLIM: 2 x Opteron 270, 16GB of RAM, RAID 10; assembly cost < 5000 EURO
- http://www.ontotext.com/owlim/

Downloads and Users – Some Statistics

- **SWRC** ontology was downloaded in total over **10k** times (tendency to exponential growth, in May 2006: 2400 times), http://ontoware.org/projects/swrc/
- Well, and there's of course the **Gene Ontology** with over **25k** downloads (constant rate of ~500 downloads per months), http://geneontology.sourceforge.net/
- **Sesame** (RDF/S repository) was downloaded in total over **30k** times (frequently over 1k downloads per month in 2006), http://www.openrdf.org/
- **Protégé** (ontology editor) has over **50k** registered users, http://protege.stanford.edu/

Semantic Web: State-of-the-art

- Tremendous research advance,
- standards are there: XML, RDF, OWL,
- matured technologies and methodologies,

… and I will help you to **build the ontology**.

Deal?

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How much?
Did he really say „Ontology“?
Ahh … and how ***do I*** evaluate the ontology?

Ontology Engineering Methodologies

- Existing methodologies include
  - Ontology Development 101
    http://protege.stanford.edu/publications/ontology_development/ontology101-noy-mcguinness.html
  - Methontology
    http://www.amazon.com/gp/product/1852335513/103-4832279-4915846?v=glance&n=283155
  - DILIGENT
    http://www.aifb.uni-karlsruhe.de/Publikationen/showPublikation?publ_id=892

- Focus on technical and organizational aspects

Blank spots:
Cost estimation and ontology evaluation

Methods for Cost Estimation

Known e.g. from Software Engineering („Software Economics“)

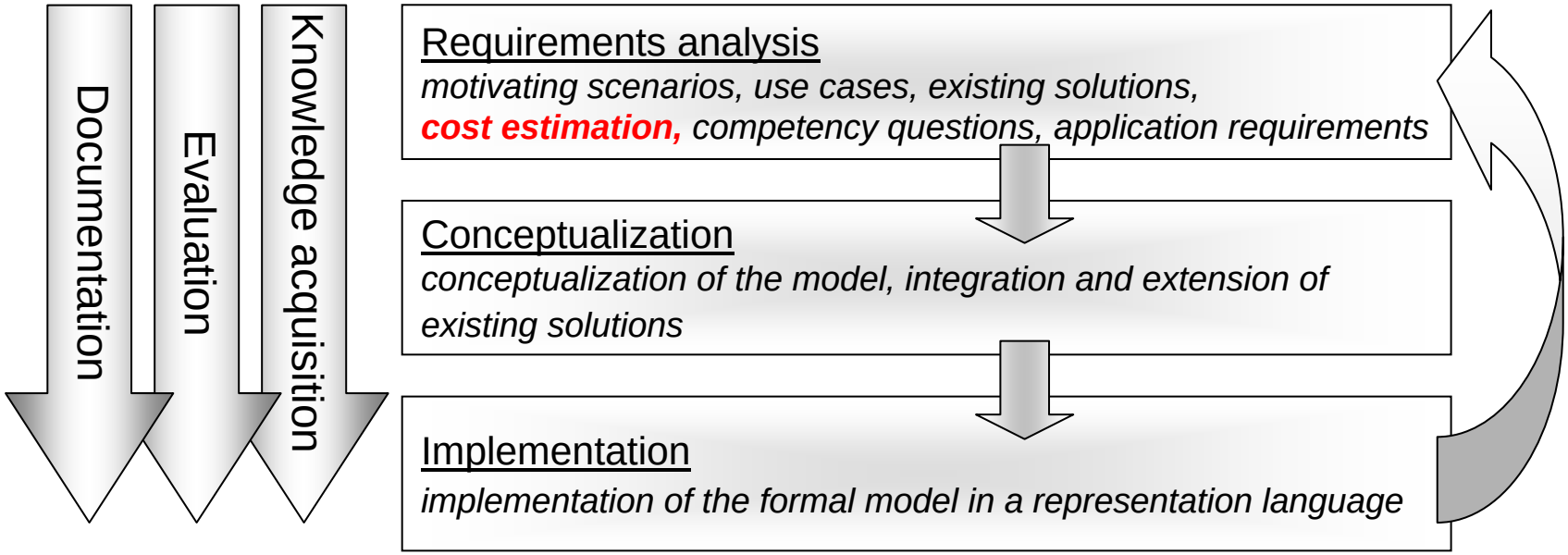
- **Analogy**
  - Extrapolation from existing projects (relies on emprical data, crucial to know the differences to current project)
- **Bottom-up**
  - Combination of individual costs for project components (application in later stages, more accurate)
- **Top-down**
  - Overall project parameters based on work break-down structures (application in early stages, less accurate)
- **Parametric/Algorithmic**
  - Identification and analysis of main cost drivers, formulas to describe their dependencies, statistical techniques to adjust formulas (requires project data for validation and calibration)
- **Expert Judgment/Delphi**
  - Questionnaires to elicit experiences from experts (potentially subjective results, frequently used)
- **Combination** balances low amount of historical data and accuracy of cost estimations

Combination of Methods

- **Top-down** breakdown of ontology engineering processes to reduce complexity
- **Parametric** method to create *a-priori* statistical prediction model
- Validation and calibration of model according to existing project **data** and **experts** estimations lead to *a-posteriori* model

Top-down Breakdown

- Common building blocks



Parametric Method

From Break-down to Equation

- PM : effort (in person months)
- A : baseline multiplicative calibration constant (in person months)
- $Size$: expected size of ontology (in kilo entities)
- α : non-linear behavior wrt. $Size$
- EM_i : effort multiplier (correspond to cost drivers, see follow-up slides)

$$PM = A * Size^{\alpha} \prod EM_i$$

Identification of Cost Drivers

- Identification of cost drivers through literature survey, expert interviews and analysis of empirical data from case studies

- Product-related
  - Domain analysis complexity
  - Required reusability
  - …
- Personnel-related
  - Ontology/Domain expert capability
  - Expertise with ontology language **(LEXP)**
  - …
- Project-related
  - Multi-site development
  - …

Definition of Effort Multipliers for Cost Driver LEXP

rating levels

increase

decrease effort

	Very Low	Low	Nominal	High	Very High
LEXP	2 months	6 months	1 year	3 years	6 years
Effort Multipliers	1.60	1.30	1.0	0.90	0.80

nominal effort

decision criteria

- Decision criteria: literature, experts, case studies
- EM values: initial assignments followed by calibration

Example

- A = 2 person months (baseline multiplicative calibration constant)
- $Size$ = 0.3 (in kilo entities)
- α = 0.9 (e.g. economies of scale)
- EM_1 = 1.6 (e.g. LEXP, 2 months exp.)
- EM_2 = 2
- EM_3 = 3

- PM = 2 * 0.3^0.9 * (1.6 * 2 * 3) = 6.49

Expert-based Evaluation and Calibration

- Based on well-known **quality framework for cost models** (honestly too much for now …)

- Setting and some results
  - Interviews with two groups
    - 4 Semantic Web academics
    - 4 researchers and 4 senior IT manager from Semantic Web related companies
  - **Validity of approach** to cost estimation and meaningful selection of **cost drivers** shown
  - Need for more finegrained coverage of **ontology evaluation**

Evaluation of Prediction Quality

- Setting
  - 36 structured interviews within 3 months
  - 35 pre-defined questions
  - Survey participants are representative for SWeb developers and users

- Some numbers
  - Average size of ontologies: 830 entities
  - Average duration: 5.3 person months
  - 40% of ontologies build from scratch
  - Reused ontologies contributed in average 50% of ontology entities

Prediction vs. Observation

- Result for *a-priori* model:
  - **75%** of the data lie in the range of adding and subtracting **75%** of the estimated effort
  - For the corresponding 30% range the model covers 32% of the real-world data
  - Currently: **Linear behavior of deviation**
  - Not bad for very first model, but we‘re **not yet there**

- **Goal: 75%** of the data lie in the range of adding and subtrackting **20%** of the estimated effort

Some Results

- **Reuse** requires better tooling
  - So far, translating and modifying reused ontologies offset expected time savings

- Analysis (for cost drivers) of **relative importance** in correlation with **significance** indicates potential for major efficiency gains e.g. in **ontology evaluation** (for more see the paper)

Much work remains to be done …

- … for **many people**:
  - Quality assurance procedures
  - Process maturity models
  - Monitoring business value and impact
  - …

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„What is Ontology?“

A Modern Approach (Second Edition)

- Morphology: Ontology = onto + log + y

- ***onto*** = moving to a location on (the surface of something)
- ***log*** = a piece of wood
- **y** = a variable, an unknown

- Thus: “Ontology”, the study of things that perch on top of pieces of wood …

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Warm-up

- Who has developed an ontology himself?
- Who has evaluated this ontology?
- Who has applied OntoClean?

OntoClean in a Nutshell

Formal Analysis of Taxonomies by Guarino and Welty

- Methodology
  - Tag concepts (properties) with meta-properties Rigidity, Unity, Identity, Dependence
  - E.g. *butterfly* +I+U-D~R, *food* +I~U+D~R, *computer* +I+U-D+R
  - Check consistency conditions
  - E.g. ~R can‘t subsume +R
  - **Food can‘t subsume computer:** An instance of computer will always be an instance of computer, whereas an instance of food does not necessarily have to be an instance of food at all points of time. So, it could stop belonging to the superclass, but still belong to the subclass - which leads to a contradiction.
- **OntoClean detects mismatches in taxonomies** and provides certain explanations for the mismatches

Rigidity

- **Rigidity.** Rigidity is based on the notion o concept is **essential** for an instance *iff* it is n essarily an instance of this concept, in **all worlds a d at all times**. *Iff* a concept is essential to a its instances, the concept is called **rigid** and is tagge n +*R*.

- An **example** of an anti-rigid con e *teacher*, as no teacher has always bee arily, a teacher, whereas ***human* is a** ecause all humans are necessarily hum ecame nor can stop being a human at so

Ahh … and how ***do I*** evaluate the ontology?

Motivation

- Understanding OntoClean requires (at least …) philosophical, modelling and particular domain knowledge
- Even for experts applying OntoClean is **tedious** and **time-consuming**

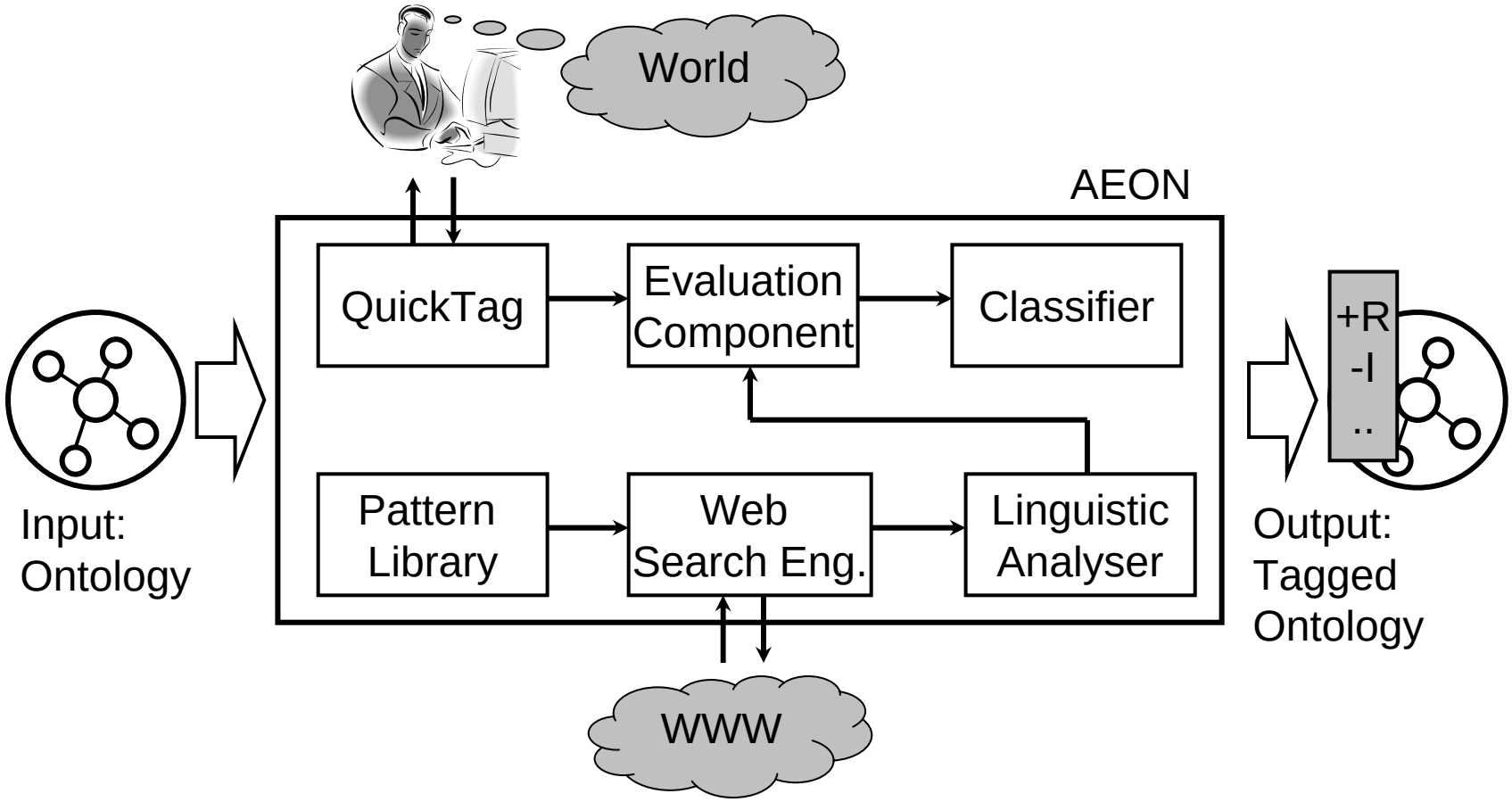
- **A**utomatic **E**valuation of **ON**tologies (AEON) *facilitates tagging wrt OntoClean meta-properties*

Approach

- Nature of concepts reflected by human language and what is said about instances of these concepts
  - „He **is no longer a student.**“ (student not rigid)
  - „Wash the product with a small **amount of water,** and air dry.“ (water does not have unity)
  - „Connecting more than **two computers** requires a hub.“ (computer is countable thus carries identity)

- **Pattern**-based approach
- Detect positive and negative **evidence** for meta-properties
- Use **WWW** as corpus
  - Overcome data-sparseness
  - Biggest source of common-sense knowledge

AEON – Architecture



AEON - Example

- Is the concept *computer* rigid (+R) or non-rigid (-R)?
- Ask Google!
  - „is no longer a computer“
  - „became a computer“
  - „while being a computer“

- Linguistic filtering: POS-Tagging, match filter patterns – e.g. „computer“ must not be followed by a word with syntactic category NN(S)/NP(S), i.e. assure that computer is not followed by one or more nouns which might constitute the head of the noun phrase
  - „Apple **is no longer a computer** company but a multimedia giant instead.“

- Determine **number of remaining ‚true‘ hits**
- Normalization: filtered hits for „computer“
- Classification features: (normalized) hits for individual patterns

- **Result: +R**

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Evaluation – Setting

- Input: Proton ontology (http://proton.semanticweb.org)
- 266 concepts, e.g. *Accident*, *Alias*, *Woman* or *Happening*, NL descriptions
- 3 human annotators (OntoClean experts)
- 7 data sets: individual taggings, human agreement
- Decision trees, 10-fold cross-validation
- Random baseline (as ‚objective' baseline)
- Measure impact of linguistic filtering (LF)

Selected Evaluation Results

- Overall: **53-67% macro-average F-Measure,** i.e. averaging F-Measure over all data sets as well as positive and negative examples (e.g. R+ and R-)

- E.g. for **Rigidity**: **87% Precision** and **91% Recall** for one specific data set (individual tagging, positive examples), and
- **74% Precision** and **79% Recall** on average over 3 data sets (individual taggings, positive examples)

- Up to **30% improvement** with linguistic filtering

Summary AEON

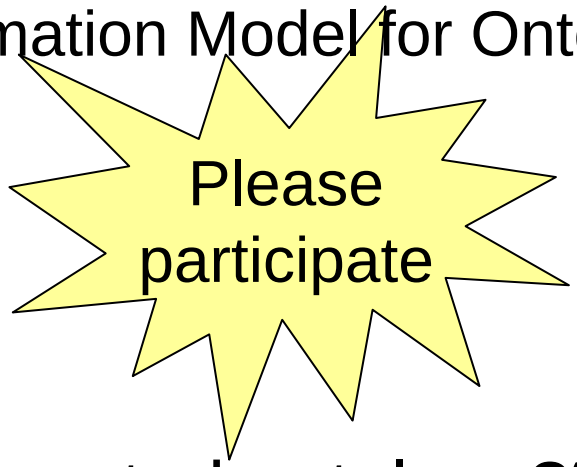
- Evaluation: 50-60% F-Measure, up to 30% improvement with linguistic filtering
- AEON
  - Facilitates application of OntoClean
  - Lowers risk of subjective taggings
- Future work
  - Provide more patterns, further evaluations

Summary ONTOCOM

- **Methodology** for creation of cost estimation formula, allows for **customization**
  - Pre-defined break-down of ontology engineering
  - Pre-defined set of cost drivers
  - Pre-defined set of effort multipliers
  - Initial value assignment
  - First round of evaluation and calibration
- Ongoing: **evaluation and calibration**

Doggy Bag

- „How much does it cost to develop ontologies?“
  - ONTOCOM: A Cost Estimation Model for Ontology Engineering
  - Online questionnaire:
    http://ontocom.ag-nbi.de/



- „How do I evaluate the created ontology?“
  - Automatic Evaluation of Ontologies (AEON)
  - Open source software available:
    http://ontoware.org/projects/aeon

Acknowledgements


ONTOCOM Team
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Denny Vrandecic, Universität Karlsruhe (TH)

EU **SEKT** integrated project,
http://www.sekt-project.org

EU **Knowledge Web** network of excellence,
http://knowledgeweb.semanticweb.org

Gossip

- **Let‘s consider: „Peter Norvig (Google Director of Search) is *in favour of* the Semantic Web“**
- Actual quote: "*What I get a lot is: 'Why are you against the Semantic Web?' I am **not against** the Semantic Web.* […]“
- Homework
  - think about negation of **antonyms**
  - apply Open World Assumption (**OWA**) and Closed World Assumption (**CWA**)
- Quote taken from: http://www.zdnet.com.au/news/software/soa/Google_exec_challenges_Berners_Lee/0,2000061733,39263931,00.htm

Disclaimer

According to §3 - §7 of the guidelines for safe use of concepts

issued by the commission for ontology evaluation,

no concepts were harmed or unsatisfiable during the creation of this slide set.

Thank You!

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http://www.york-sure.de/

Talk is based on …

- **ONTOCOM: A Cost Estimation Model for Ontology Engineering**
  Elena Paslaru Bontas Simperl, Christoph Tempich, and York Sure.
  Accepted for publication. To appear in: Proceedings of the 5th International Semantic Web Conference (ISWC2006), November 5-9, 2006, Athens, GA, US, LNCS. Springer Verlag.

- **Automatic Evaluation of Ontologies (AEON)**
  Johanna Völker, Denny Vrandecic, and York Sure.
  In: Yolanda Gil, Enrico Motta, V. Richard Benjamins, and Mark A. Musen (Eds.) *Proceedings of the 4th International Semantic Web Conference (ISWC2005), November 6-10, 2005, Galway, Ireland*, pages 716-731, volume 3729 of *LNCS*. Springer Verlag Berlin-Heidelberg.

OntoClean Reference

- N. Guarino and C. A. Welty. A formal ontology of properties. In *Knowledge Acquisition, Modeling and Management*, pages 97–112, 2000.

Rigidity

- **Rigidity.** Rigidity is based on the notion of *essence*. A concept is **essential** for an instance *iff* it is necessarily an instance of this concept, in all worlds and at all times. *Iff* a concept is essential to all of its instances, the concept is called **rigid** and is tagged with +*R*.

- An **example** of an anti-rigid concept would be *teacher*, as no teacher has always been, nor is necessarily, a teacher, whereas *human* is a rigid concept because all humans are necessarily humans and neither became nor can stop being a human at some time.

Unity

- **Unity.** Unity is about “What is part of something and what is not?” This answer is given by an **Unity Criterion** (UC), which is true for all parts of an instance of this concept, and for nothing else.

- For **example**, there is an unity criterion for the parts of a human body, as we can say for every human body which parts belong to it.

Identity

- **Identity.** A concept with Identity is one, where the instances can be identified as being the same at any time and in any world, by virtue of this concept. This means that the concept carries an **Identity Criterion** (IC). It is tagged with +*I*, and with -*I* otherwise.

- For **example**, the concept *human* carries an IC, as we are able to identify someone as being the same or not, even though we may not be able to say what IC we actually used for that. On the other hand, a concept like *red* would be tagged -*I*, as we cannot tell instances of red apart because of its color.

Dependence

- **Dependence.** A concept *C*1 is dependent on a concept *C*2 (and thus tagged +*D*), *iff* for every instance of *C*1 an instance of *C*2 must exist.

- An **example** for a dependent concept would be *food*, as instances of food can only exist if there is something for which these instances are food.