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Ontology Engineering for the Semantic Web and beyond...

Eva Blomqvist

Department of Computer and Information Science (IDA)

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Outline

About me
The Semantic Web
Ontologies

- > Ontology Design Patterns
- > eXtreme Design
- ➢ My research at IDA

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About me

- Studied at LiU's D-program 1996-2003
- PhD student at Jönköping University registered here at IDA
 - > Defended my thesis in April 2009
 - "Semi-automatic Ontology Construction based on Patterns"
- Postdoc at the Semantic Technologies Lab, ISTC-CNR in Rome, Italy (20 months)
 - Mainly worked on two large European projects: NeOn and IKS
 - > eXtreme Design
- Quick stopover in Jönköping 2010-2011 mainly teaching
- Since July 2011 "Forskarassistent" at IDA
 - Financed by SecurityLink
 - Improve decision support by means of semantic technologies
 - Applications in security and crisis management

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The Semantic Web

- Original vision [6]
 - Agents operate on our behalf on the web
 - Based on the "machine understandable web"
- How could this work?
 - Content on the web has to be created differently than normal web pages – not only machine "readable" but "understandable"



- Semantics (meaning) has to be encoded within the pages, in order to allow software (agents) make use of all the information
- We need to be able to identify everything also things outside the web – in order to talk about them – URIs

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The Semantic Web – Are we there?

- Standard languages for expressing data and semantics on the web, as well as query the data
 - RDF(S), OWL, SPARQL, RDFa, …
- Tons of data [7-9]
 - Linked data initiative
 publishing RDF data according to some simple guidelines
- > But...
 - Few datasets make use of expressive ontologies
 - People find it hard to build them
 - Only a few existing ontologies are reused and few ontologies are linked
 - Ontology alignment is a key
 - Still too complex to publish "semantic content"

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What are ontologies?

- The things that encode the meaning of something on the Semantic Web
 - The thing that defines the "tags"
 - Practically: an online file containing expressions in a logical language, most probably OWL, defining some concepts and relations used by data on the Semantic Web
- More philosophically
 - > A model of the world (or some hypothetical world)
- Challenges
 - Several traditions create diverse opinions and disputes
 - Focus on "philosophical correctness" or functionality?
 - Focus on coverage or task?

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"Now! ... That should clear up a few things around here!"

January 16, 2012

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Let's kill the myths...



- Ontologies are a new thing?
 - Not even computational ontologies are a new thing (c.f. expert systems, AI etc.) – What is new is that we have standard languages and share them on the web => "critical mass" of models and data!
- Ontologies have come to make DBs obsolete?
 - You can do the same things with many DBs (c.f. deductive databases etc.) – Ok, it is more expressive than a traditional relational DB, but can be used to similar things, just in a more "webby" way. Many triples stores (storage for ontology data) use DBMS at the backend for efficiency.
- It's not a scalable approach on the web?
 - We are still to see a truly scalable reasoner over OWL, but with localized reasoning etc. it usually works in practice.

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Ontology Design Patterns – Why?



- When the web exploded it was because everybody could create their own website in an afternoon!
 The Semantic Web is not that easy... not even for developers
 You don't need to understand the formal semantics of the Java language in order to start using it – you start from examples
 Similarly, ontology engineers want to care only about what they need and use good examples in order to start modelling...
 ... but examples should show high-quality solutions
 Reuse of complete ontologies has been encouraged – but seldom works well
 We all have different requirements and viewpoints
 - We often just want to reuse a small piece of the model

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Ontology Design Patterns – What?

- Typical solutions to design, transformation, or usage problems in ontology engineering – (ideally) based on best practices
- Different types of ODPs
 - Logical ODPs [11-13] independent of any conceptualization (logical templates "without signature")
 - Example: n-ary relations
 - Content ODPs [13] instantiations of Logical ODPs in a certain domain (templates with signature – domain may be very generic)
 - Correspondence ODPs transformations and correspondences between different modelling styles, languages, etc.
 - Presentation ODPs annotation schemas for documentation, naming conventions, etc.

▶ .

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Content ODPs - Example

Common way to model roles... "roles as classes"



- An object and its roles are related through the rdf:type property
- rdf:type relations can be either asserted or inferred through classification
- In order to automatically classify individuals in a certain class the ontology has to define appropriate axioms

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Roles as Classes

Consequences

- Roles are described at TBox level
- Class taxonomy is bigger a class for each role



- Class taxonomy is entangled multi-typing
- > ABox is smaller same individual, several (roles) types
- Automatic classification of individuals through rdfs:subClassOf inheritance – with proper axioms
- > Roles cannot be indexed in terms of space and time
- Facts about roles cannot be easily expressed e.g. "Roles in LiU are student, professor, researcher", "Eva is a teacher of the IR course"
- > Queries: ?x a SongWriter

Roles as Individuals



- Relations between an object and its roles have to be asserted
- Automatic inference of relations between an object and its roles can be obtained through property subsumption



Person

hasRole

Role

rdf:type

sax_player

Roles as Individuals



- Consequences
 - Roles are described at ABox level
 - Class taxonomy is smaller roles are individuals
 - Abox is bigger
 - Facts on roles can be asserted
 - N-ary relations are needed for relating an object to its role with respect to some other object e.g. Valentina is a teacher in a specific course
 - Roles do not type objects, no automatic classification of objects
 - > Queries: ?x hasRole ?y; ?x a Role

Roles as Properties



- The semantics of "having a role" is embedded in the name of a property
- Objects are not explicitly related to their roles, they are related to other things through a property expressing an action they perform, a role they play
- Most common pattern in the web of data for modeling roles





Roles as Properties

Consequences

- Small taxonomy of classes
- Bigger taxonomy of properties a property for each role
- Simpler graph of data one triple for "Eva is a teacher in the IR course"
- Roles cannot be indexed in terms of space and time
- Semantics of roles is implicit (embedded in a property name)
- Facts about roles cannot be easily expressed
- > Queries: ?x teaches ?y



Content ODPs – Example: Roles

- The three solutions differ in expressivity, simplicity, and requirements they can solve
 - Simplest is roles as properties
 - Most expressive is roles as individuals
- Each of them has pros and cons The choice depends on your requirements
- Correspondence ODPs can tell you how to transform btw them
- Can also be combined...



The ODP Portal [13]

- One of the catalogues collecting ODPs
 - Open online community
 anyone can contribute
- http://ontologydesignpatterns.org
- Content ODPs for roles of objects
 - Object-Role
 - OWL pattern representing roles as individuals
 - http://ontologydesignpatterns.org/cp/owl/dul/objectrole.owl
 - Time-place-indexed-object-role
 - N-ary relation representing objects, and the roles they play at a certain time in a certain place
 - http://www.ontologydesignpatterns.org/cp/owl/dul/ timeplaceindexedobjectrole.owl



RI4D.

eXtreme Design – Why?

We wanted...

- Something radically different from existing methodologies
- Something more suitable for ODP reuse
- Classical ontology engineering methodologies are
 - > Waterfall style
 - Not very detailed
 - Do not focus on collaboration
 - Do not focus on requirements and their verification
- So what would be the opposite?
 - An incremental methodology
 - With detailed steps for the actual design process
 - Where small teams collaborate to create the ontology piece by piece
 - Where the problem is broken down into small pieces, each with their own requirements that are later tested and verified

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XD - Studies and Results

- Three rounds of studies
 - Subjects: master and graduate students, researchers
 - Setting: mainly courses and conference tutorials
- First round: Do ODPs make a difference? [3]
 - Quality of ontologies is increased primarily with respect to the usability dimension
 - They are somewhat difficult to understand and use tool support?
- Second round: Does XD add anything? [4]
 - Mandatory testing increases quality in the functional dimension
 - With tool support learning curve looks better
- Third round: How to arrange the collaboration and integration?
 - Ongoing work…

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Current Research at IDA

- How can ontologies and Semantic Web technologies help us make better decisions?
 - Good decisions are essential in security and crisis management scenarios
- Potential tasks
 - > Information filtering and integration
 - Information enrichment
 - Detecting "patterns" in data analysing the situation
 - Tracking and sharing decision information – metalevel [2]
- For all these tasks we need appropriate ontologies
 - > What ODPs apply?
 - How can developers use them to build effective applications?
 - Large dynamic and evolving datasets

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Current research at IDA – Application Example

- Demo application with Jordbruksverket
- Analysing the situation for "plant protection" detecting potentially dangerous situations in our farmland



Research Interests in Summary

Semantic Web and Linked Data

- > Ontology Engineering
- Publishing Linked Data
- "Open government"
- Ontology-based applications
- Security and Crisis Management
 - Information-intense situations and applications
 - Complex event processing and situation awareness

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Publications

- [1] Presutti V., Blomqvist E., Daga E., and Gangemi A.: Pattern-based Ontology Design. To appear in: Suárez-Figueroa, M.C.; Gómez-Pérez, A.; Motta, E.; Gangemi, A. (Eds.) Ontology Engineering in a Networked World, Springer, 2012.
- Blomqvist E., Ceruti M., Waters J., and McGarry D.: A Decision-making Format for
- [2] the Semantic Web. In: Proceedings of the 2nd International Workshop on Ontology Patterns - WOP2010, ISWC2010 Workshops Volume VIII, CEUR workshop proceedings, Vol-671, 2010.
- [3] Blomqvist E., Presutti V., Daga E., and Gangemi A.: Experimenting with eXtreme Design. In: Proceedings of EKAW 2010 - Knowledge Engineering and Knowledge Management by the Masses, Lisbon, October 11-15, Lecture Notes in Computer Science, Springer, 2010.
- [4] Blomqvist E., Gangemi A. and Presutti V.: Experiments on pattern-based ontology design. In: Proceedings of the 5th International Conference on Knowledge Capture (K-CAP 2009), September 1-4, 2009, Redondo Beach, California, USA. pp. 41-48, ACM, 2009.
- [5] Blomqvist E.: OntoCase-Automatic Ontology Enrichment Based on Ontology Design Patterns. In: The Semantic Web - ISWC 2009, 8th International Semantic Web Conference, ISWC 2009, Chantilly, VA, USA, October 25-29, 2009. Proceedings. pp. 65-80, Lecture Notes in Computer Science, Springer, 2009.

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Useful Links

- Original article from 2001 with the Semantic Web vision: [6] http://www.scientificamerican.com/article.cfm?id=the-semantic-web
- TED-talk by Tim Berners-Lee on linked data: [7] http://www.ted.com/talks/tim berners lee on the next web.html
- Linked Data initiative: [8] http://linkeddata.org/
- Article on Linked Data: [9] http://tomheath.com/papers/bizer-heath-berners-lee-ijswis-linked-data.pdf
- Semantic Web tutorial from ISWC2008 (set of talks good introduction by [10] Jim Hendler talking about the different perspectives on ontologies): http://videolectures.net/iswc08 hendler ittsw/

- **Ontology Design Pattern catalogues** Initial catalogue of Logical ODPs (for OWL1) from the W3C: <u>http://www.w3.org/2001/sw/BestPractices/OEP/</u> [11]
- Logical ODPs from Manchester University: [12] http://www.gong.manchester.ac.uk/odp/html/index.html
- The ODP portal (different types of ODPs): [13] http://ontologydesignpatterns.org/

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