

Chapter 6 Applications

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Lecture Outline

1. Horizontal Information Products at Elsevier
2. Data Integration at Audi
3. Skill Finding at Swiss Life
4. Think Tank Portal at EnerSearch
5. E-Learning
6. Web Services
7. Other Scenarios

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Elsevier – The Setting

- Elsevier is a leading scientific publisher.
- Its products are organized mainly along traditional lines:
 - Subscriptions to journals
- Online availability of these journals has until now not really changed the organisation of the productline
- Customers of Elsevier can take subscriptions to online content

Elsevier – The Problem

- Traditional journals are vertical products
- Division into separate sciences covered by distinct journals is no longer satisfactory
- Customers of Elsevier are interested in covering certain topic areas that spread across the traditional disciplines/journals
- The demand is rather for **horizontal products**

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Elsevier – The Problem (2)

- Currently, it is difficult for large publishers to offer such horizontal products
 - Barriers of physical and syntactic heterogeneity can be solved (with XML)
 - The semantic problem remains unsolved
- We need a way to search the journals on a coherent set of concepts against which all of these journals are indexed

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Elsevier – The Contribution of Semantic Web Technology

- Ontologies and thesauri (very lightweight ontologies) have proved to be a key technology for effective information access
 - They help to overcome some of the problems of free-text search
 - They relate and group relevant terms in a specific domain
 - They provide a controlled vocabulary for indexing information

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Elsevier – The Contribution of Semantic Web Technology (2)

- A number of thesauri have been developed in different domains of expertise
 - Medical information: MeSH and Elsevier's life science thesaurus EMTREE
- RDF is used as an interoperability format between heterogeneous data sources
- EMTREE is itself represented in RDF

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Elsevier – The Contribution of Semantic Web Technology (3)

- Each of the separate data sources is mapped onto this unifying ontology
 - The ontology is then used as the single point of entry for all of these data sources

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Audi – The Problem

- Data integration is also a huge problem internal to companies
 - It is the highest cost factor in the information technology budget of large companies
 - Audi operates thousands of databases
- Traditional middleware improves and simplifies the integration process
 - [But it misses the sharing of information based on the semantics of the data](#)

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Audi – The Contribution of Semantic Web Technology

- Ontologies can rationalize disparate data sources into one body of information
- Without disturbing existing applications, by:
 - creating ontologies for data and content sources
 - adding generic domain information
- The ontology is mapped to the data sources giving applications direct access to the data through the ontology

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Audi – Camera Example

```
<SLR rdf:ID="Olympus-OM-10">
  <viewFinder>twin mirror</viewFinder>
  <optics>
    <Lens>
      <focal-length>75-300mm zoom</focal-length>
      <f-stop>4.0-4.5</f-stop>
    </Lens>
  </optics>
  <shutter-speed>1/2000 sec. to 10 sec.</shutter-speed>
</SLR>
```

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Audi – Camera Example (2)

```
<Camera rdf:ID="Olympus-OM-10">
  <viewFinder>twin mirror</viewFinder>
  <optics>
    <Lens>
      <size>300mm zoom</size>
      <aperture>4.5</aperture>
    </Lens>
  </optics>
  <shutter-speed>1/2000 sec. to 10 sec.</shutter-speed>
</Camera>
```

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Audi – Camera Example (3)

- Human readers can see that these two different formats talk about the same object
 - We know that SLR is a kind of camera, and that **fstop** is a synonym for **aperture**
- Ad hoc integration of these data sources by translator is possible
- Would only solve this specific integration problem
- We would have to do the same again when we encountered the next data format for cameras

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Audi – Camera Ontology in OWL

```
<owl:Class rdf:ID="SLR">
  <rdfs:subClassOf rdf:resource="#Camera"/>
</owl:Class>
<owl:DatatypeProperty rdf:ID="f-stop">
  <rdfs:domain rdf:resource="#Lens"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="aperture">
  <owl:equivalentProperty rdf:resource="#f-stop"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="focal-length">
  <rdfs:domain rdf:resource="#Lens"/>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="size">
  <owl:equivalentProperty rdf:resource="#focal-length"/>
</owl:DatatypeProperty>
```

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Audi – Using the Ontology

- Suppose that an application A
 - is using the second encoding
 - is receiving data from an application B using the first encoding
- Suppose it encounters **SLR**
 - Ontology returns “**SLR** is a type of **Camera**”
 - A relation between something it doesn't know (**SLR**) to something it does know (**Camera**)

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Audi – Using the Ontology (2)

- Suppose A encounters **f-stop**
 - The Ontology returns: “**f-stop** is synonymous with **aperture**”
- Bridges the terminology gap between something A doesn't know to something A does know
- Syntactic divergence is no longer a hindrance

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Swiss Life – The Setting

- Swiss Life is one of Europe's leading life insurers
 - 11,000 employees, \$14 billion of written premiums
 - Active in about 50 different countries
- The most important resources of any company for solving knowledge intensive tasks are:
 - The tacit knowledge, personal competencies, and skills of its employees

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Swiss Life – The Problem

- One of the major building blocks of **enterprise knowledge management** is:
 - An electronically accessible repository of people's capabilities, experiences, and key knowledge areas
- A **skills repository** can be used to:
 - enable a search for people with specific skills
 - expose skill gaps and competency levels
 - direct training as part of career planning
 - document the company's intellectual capital

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Swiss Life – The Problem (2)

- Problems
 - How to list the large number of different skills?
 - How to organise them so that they can be retrieved across geographical and cultural boundaries?
 - How to ensure that the repository is updated frequently?

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Swiss Life – The Contribution of Semantic Web Technology

- Hand-built ontology to cover skills in three organizational units
 - Information Technology, Private Insurance and Human Resources
- Individual employees within Swiss Life were asked to create “home pages” based on form filling driven by the skills-ontology
- The corresponding collection could be queried using a form-based interface that generated RQL queries

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Swiss Life – Skills Ontology

```
<owl:Class rdf:ID="Skills">
  <rdfs:subClassOf>
    <owl:Restriction>
      <owl:onProperty rdf:resource="#HasSkillsLevel"/>
      <owl:cardinality
        rdf:datatype="&xsd;nonNegativeInteger">
        1</owl:cardinality>
    </owl:Restriction>
  </rdfs:subClassOf>
</owl:Class>
<owl:ObjectProperty rdf:ID="HasSkills">
  <rdfs:domain rdf:resource="#Employee"/>
  <rdfs:range rdf:resource="#Skills"/>
</owl:ObjectProperty>
```

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Swiss Life – Skills Ontology (2)

```
<owl:ObjectProperty rdf:ID="WorksInProject">
  <rdfs:domain rdf:resource="#Employee"/>
  <rdfs:range rdf:resource="#Project"/>
  <owl:inverseOf rdf:resource="#ProjectMembers"/>
</owl:ObjectProperty>
<owl:Class rdf:ID="Publishing">
  <rdfs:subClassOf rdf:resource="#Skills"/>
</owl:Class>
<owl:Class rdf:ID="DocumentProcessing">
  <rdfs:subClassOf rdf:resource="#Skills"/>
</owl:Class>
```

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Swiss Life – Skills Ontology (3)

```
<owl:ObjectProperty rdf:ID="ManagementLevel">
  <rdfs:domain rdf:resource="#Employee"/>
  <rdfs:range>
    <owl:oneOf rdf:parseType="Collection">
      <owl:Thing rdf:about="#member"/>
      <owl:Thing rdf:about="#HeadOfGroup"/>
      <owl:Thing rdf:about="#HeadOfDept"/>
      <owl:Thing rdf:about="#CEO"/>
    </owl:oneOf>
  </rdfs:range>
</owl:ObjectProperty>
```

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EnerSearch – The Setting

- An industrial research consortium focused on information technology in energy
- EnerSearch has a structure very different from a traditional research company
 - Research projects are carried out by a varied and changing group of researchers spread over different countries
 - Many of them are not employees of EnerSearch

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EnerSearch – The Setting (2)

- EnerSearch is organized as a virtual organization
- Owned by a number of firms in the industry sector that have an express interest in the research being carried out
- Because of this wide geographical spread, EnerSearch also has the character of a virtual organisation from a knowledge distribution point of view

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EnerSearch – The Problem

- Dissemination of knowledge key function
- The information structure of the web site leaves much to be desired
- It does not satisfy the needs of info seekers, e.g.
 - Does load management lead to cost-saving?
 - If so, what are the required upfront investments?
 - Can powerline communication be technically competitive to ADSL or cable modems?

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EnerSearch – The Contribution of Semantic Web Technology

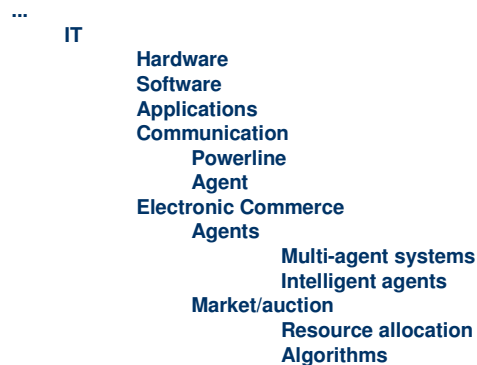
- It is possible to form a clear picture of what kind of topics and questions would be relevant for these target groups
- It is possible to define a domain ontology that is sufficiently stable and of good quality
 - This lightweight ontology consisted only of a taxonomical hierarchy
 - Needed only RDF Schema expressivity

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EnerSearch – Lunchtime Ontology



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EnerSearch – Use of Ontology

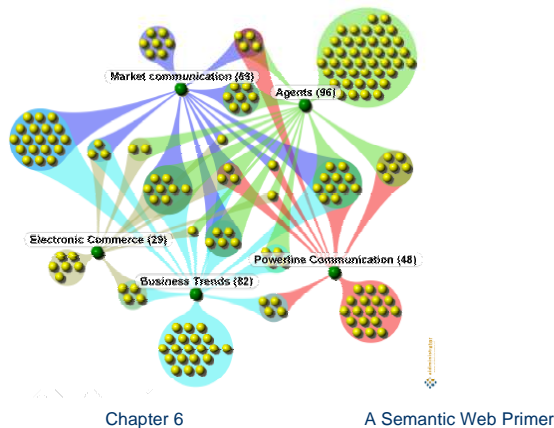
- Used in a number of different ways to drive navigation tools on the EnerSearch web site
 - Semantic map of the EnerSearch web site
 - Semantic distance between EnerSearch authors in terms of their fields of research and publication

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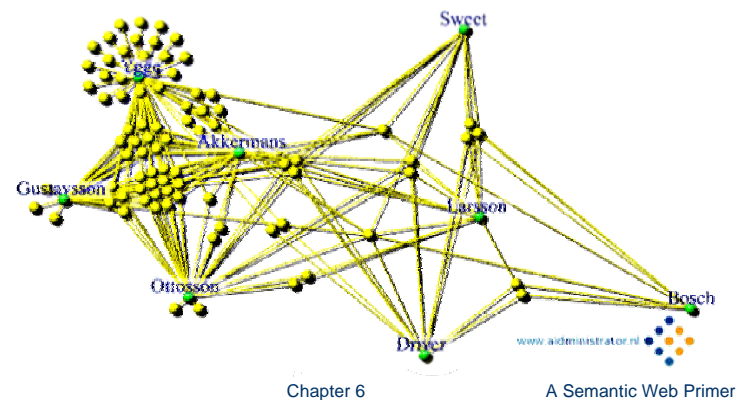
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Semantic Map of Part of the EnerSearch Web Site



Semantic Distance between EnerSearch Authors



EnerSearch – QuizRDF

- QuizRDF aims to combine
 - an entirely ontology based display
 - a traditional keyword based search without any semantic grounding
- The user can type in general keywords
- It also displays those concepts in the hierarchy which describe these papers
- All these disclosure mechanisms (textual and graphic, searching or browsing) based on a single underlying lightweight ontology

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E-Learning – The Setting

- Traditionally learning has been characterized by the following properties:
 - Educator-driven
 - Linear access
 - Time- and locality-dependent
 - Learning has not been personalized but rather aimed at mass participation

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E-Learning – The Setting (2)

- The changes are already visible in **higher education**
 - Virtual universities
 - Flexibility and new educational means
 - Students can increasingly make choices about pace of learning, content, evaluation methods

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E-Learning – The Setting (3)

- Even greater promise: **life long learning activities**
 - Improvement of the skills of its employees is critical to companies
 - Organizations require learning processes that are just-in-time, tailored to their specific needs
 - These requirements are not compatible with traditional learning, but e-learning shows great promise for addressing these concerns

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E-Learning – The Problem

- E-learning is not driven by the instructor
- Learners can:
 - Access material in an order that is not predefined
 - Compose individual courses by selecting educational material
- Learning material must be equipped with additional information (metadata) to support effective indexing and retrieval

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E-Learning – The Problem (2)

- Standards (IEEE LOM) have emerged
 - E.g. educational and pedagogical properties, access rights and conditions of use, and relations to other educational resources
- Standards suffer from **lack of semantics**
 - This is common to all solutions based solely on metadata (XML-like approaches)
 - Combining of materials by different authors may be difficult
 - Retrieval may not be optimally supported
 - Retrieval and organization of learning resources must be made manually
 - Could be done by a personalized automated agent instead!

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E-Learning – The Contribution of Semantic Web Technology

- Establish a promising approach for satisfying the e-learning requirements
 - E.g. ontology and machine-processable metadata
- **Learner-centric**
 - Learning materials, possibly by different authors, can be linked to commonly agreed ontologies
 - Personalized courses can be designed through semantic querying
 - Learning materials can be retrieved in the context of actual problems, as decided by the learner

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E-Learning – The Contribution of Semantic Web Technology (2)

- **Flexible access**
 - Knowledge can be accessed in any order the learner wishes
 - Appropriate semantic annotation will still define prerequisites
 - Nonlinear access will be supported
- **Integration**
 - A uniform platform for the business processes of organizations
 - Learning activities can be integrated in these processes

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Ontologies for E-Learning

- Some mechanism for establishing a shared understanding is needed: ontologies
- In e-learning we distinguish between three types of knowledge (ontologies):
 - Content
 - Pedagogy
 - Structure

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Content Ontologies

- Basic concepts of the domain in which learning takes place
- Include the relations between concepts, and basic properties
 - E.g., the study of **Classical Athens** is part of the *history of Ancient Greece*, which in turn is part of **Ancient History**
 - The ontology should include the relation “*is part of*” and the fact that it is transitive (e.g., expressed in OWL)
- COs use relations to capture synonyms, abbreviations, etc.

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Pedagogy Ontologies

- Pedagogical issues can be addressed in a pedagogy ontology (PO)
- E.g. material can be classified as lecture, tutorial, example, walk-through, exercise, solution, etc.

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Structure Ontologies

- Define the logical structure of the learning materials
- Typical knowledge of this kind includes hierarchical and navigational relations like **previous**, **next**, **hasPart**, **isPartOf**, **requires**, and **isBasedOn**
- Relationships between these relations can also be defined
 - E.g., **hasPart** and **isPartOf** are inverse relations
- Inferences drawn from learning ontologies cannot be very deep

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Web Services

- Web sites that do not merely provide static information, but involve interaction with users and often allow users to effect some action
- **Simple Web services** involve a single Web-accessible program, sensor, device
- **Complex Web services** are composed of simpler services
 - Often they require ongoing interaction with the user
 - The user can make choices or provide information conditionally

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A Complex Web Service

- User interaction with an online music store involves
 - searching for CDs and titles by various criteria
 - reading reviews and listening to samples
 - adding CDs to a shopping cart
 - providing credit card details, shipping details, and delivery address

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Web Services – Contribution of Semantic Web Technology

- Use machine-interpretable descriptions of services to automate:
 - discovery, invocation, composition and monitoring of Web services
- Web sites should be able to employ a set of basic classes and properties by declaring and describing services: **ontology of services**

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DAML-S and OWL-S

- DAML-S is an initiative that is developing an ontology language for Web services
- It makes use of DAML+OIL
- It can be viewed as a layer on top of DAML+OIL
- OWL-S is more recent version on top of OWL

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Three Basic Kinds of Knowledge Associated with a Service

- Service profile
 - Description of the offerings and requirements of a service
 - Important for service discovery
- Service model
 - Description of how a service works
- Service grounding
 - communication protocol and port numbers to be used in contacting the service

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Service Profiles

- Describe services offered by a Web site
- A service profile in DAML-S provides the following information:
 - A human-readable description of the service and its provider
 - A specification of the functionalities provided by the service
 - Additional information, such as expected response time and geographic constraints
- Encoded in the modeling primitives of DAML-S:
- E.g. classes and properties defined in DAML+OIL

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Service Profiles (2)

```
<rdfs:Class rdf:ID="OfferedService">
  <rdfs:label>OfferedService</rdfs:label>
  <rdfs:subClassOf rdf:resource=
    "http://www.daml.org/services/daml-s/
    2001/10/Service.daml#" />
</rdfs:Class>
```

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Service Profiles (3)

- Properties defined on this class:
 - **intendedPurpose** (range = string)
 - **serviceName** (range = string)
 - **providedBy** (range = is a new class, **Service-Provider**, which has various properties)

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Functional Description of Web Services

- **input** describes the parameters necessary for providing the service
 - E.g., a sports news service might require the following input:
 - date, sports category, customer credit card details.
- **output** specifies the outputs of the service
 - In the sports news example, the output would be the news articles in the specified category at the given date

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Functional Description of Web Services (2)

- **precondition** specifies the conditions that need to hold for the service to be provided effectively
 - The distinction between inputs and preconditions can be illustrated in our running example:
 - The credit card details are an input, and preconditions are that the credit card is valid and not overcharged
- **effect** specifies the effects of the service
 - In our example, an effect might be that the credit card is charged \$1 per news article

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Service Models

- Based on the key concept of a **process**, which describes a service in terms of
 - inputs, outputs, preconditions, effects, and
 - its composition of component subprocesses
- **Atomic processes** can be directly invoked by passing them appropriate messages; they execute in one step
- **Simple processes** are elements of abstraction; they have single-step executions but are not invocable
- **Composite processes** consist of other, simpler processes

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Composition of Processes

- A composite process is composed of a number of control constructs:

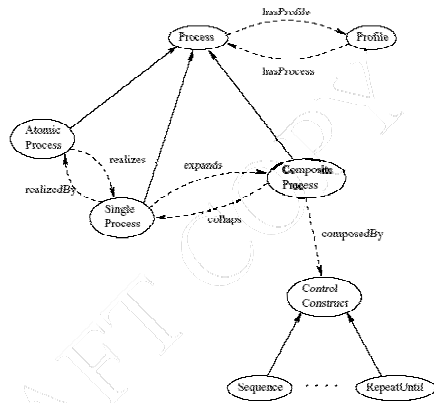
```
<rdf:Property rdf:ID="composedBy">
  <rdfs:domain rdf:resource="#CompositeProcess"/>
  <rdfs:range rdf:resource="#ControlConstruct"/>
</rdf:Property>
```
- Control constructs offered by DAML-S include:
 - sequence, choice, if-then-else and repeat-until

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Top Level of the Process Ontology



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Multimedia Collection Indexing at Scotland Yard

- Theft of art and antique objects
- International databases of stolen art objects exist
 - It is difficult to locate specific objects in these databases
 - Different parties are likely to offer different descriptions
 - Human experts are needed to match objects to database entries

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Multimedia Collection Indexing at Scotland Yard – The Solution

- Develop controlled vocabularies such as the Art and Architecture Thesaurus (AAT) from the Getty Trust, or Iconclass thesaurus
- Extend them into full-blown ontologies
- Develop automatic classifiers using ontological background knowledge
- Deal with the ontology-mapping problem

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Online Procurement at Daimler-Chrysler – The Problem

- Static, long-term agreements with a fixed set of suppliers can be replaced by dynamic, short-term agreements in a competitive open marketplace
- Whenever a supplier is offering a better deal, Daimler-Chrysler wants to be able to switch
- Major drivers behind B2B e-commerce

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Online Procurement at Daimler-Chrysler – The Solution

- Rosetta Net is an organization dedicated to such standardization efforts
- XML-based, no semantics
- Use RDF Schema and OWL instead
 - Product descriptions would “carry their semantics on their sleeve”
 - Much more liberal online B2B procurement processes would exist than currently possible

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Device Interoperability at Nokia

- Explosive proliferation of digital devices:
 - PDAs, mobiles, digital cameras, laptops, wireless access in public places, GPS-enabled cars
- **Interoperability** among these devices?
- The pervasiveness and the wireless nature of these devices require network architectures to support **automatic, ad hoc configuration**
- A key technology of true ad hoc networks is **service discovery**

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Device Interoperability at Nokia (2)

- Current service discovery and capability description require a priori identification of what to communicate or discuss
- A more attractive approach would be “*serendipitous interoperability*”
 - Interoperability under “unchoreographed” conditions
 - Devices necessarily designed to work together

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Device Interoperability at Nokia (3)

- These devices should be able to:
 - Discover each others' functionality
 - Take advantage of it
- Devices must be able to “understand” other devices and reason about their functionality
- Ontologies are required to make such “unchoreographed” understanding of functionalities possible