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

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

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

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

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

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

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

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>
```

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>
```

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

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>
```

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**)

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

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

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?

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

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>
```

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>
```

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

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

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?

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

EnerSearch – Lunchtime Ontology

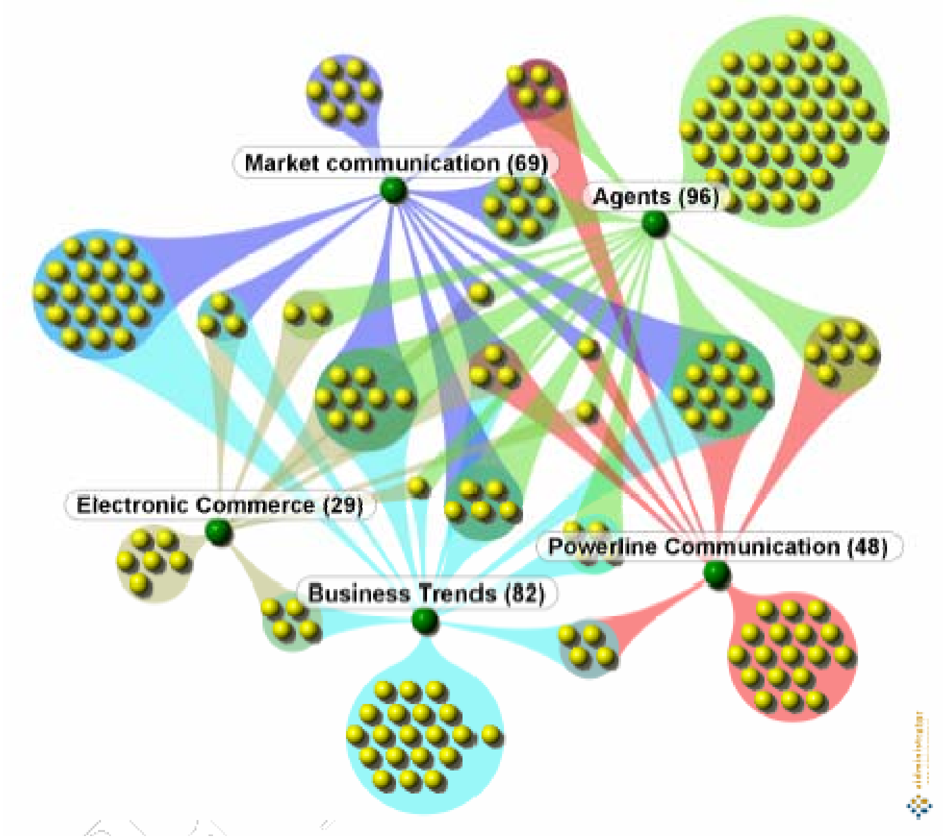
...

- **IT**
  - **Hardware**
  - **Software**
  - **Applications**
  - **Communication**
    - **Powerline**
    - **Agent**
  - **Electronic Commerce**
    - **Agents**
      - **Multi-agent systems**
      - **Intelligent agents**
    - **Market/auction**
      - **Resource allocation**
      - **Algorithms**

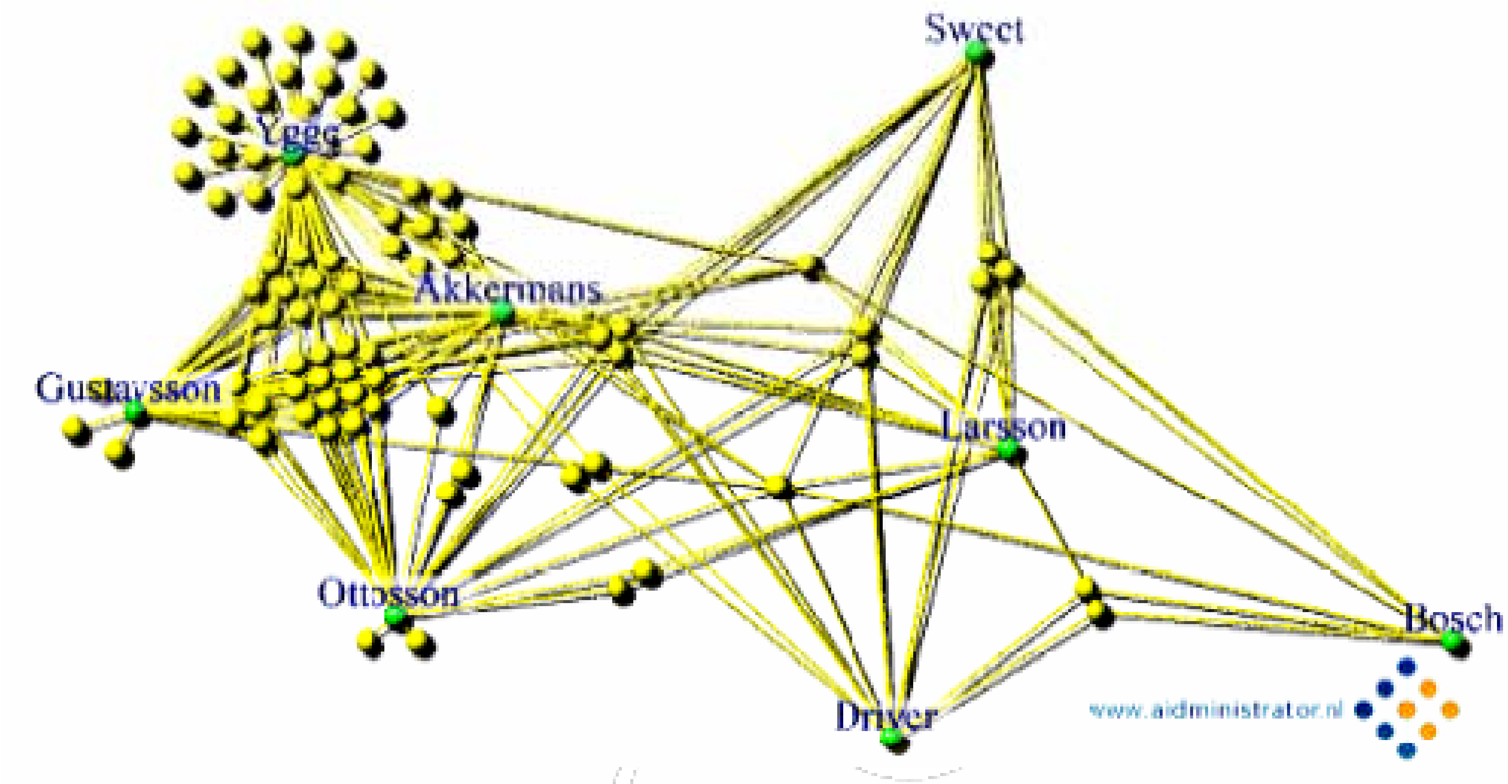
EnerSearch – Use of Ontology

- 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

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

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

E-Learning – The Setting (3)

- Even greater promise: **life long learning activities**
  - Improvement of the skills of its employees ic 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

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

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!

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

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

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

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.

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.

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

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

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

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

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

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

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>
```

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)

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

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

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

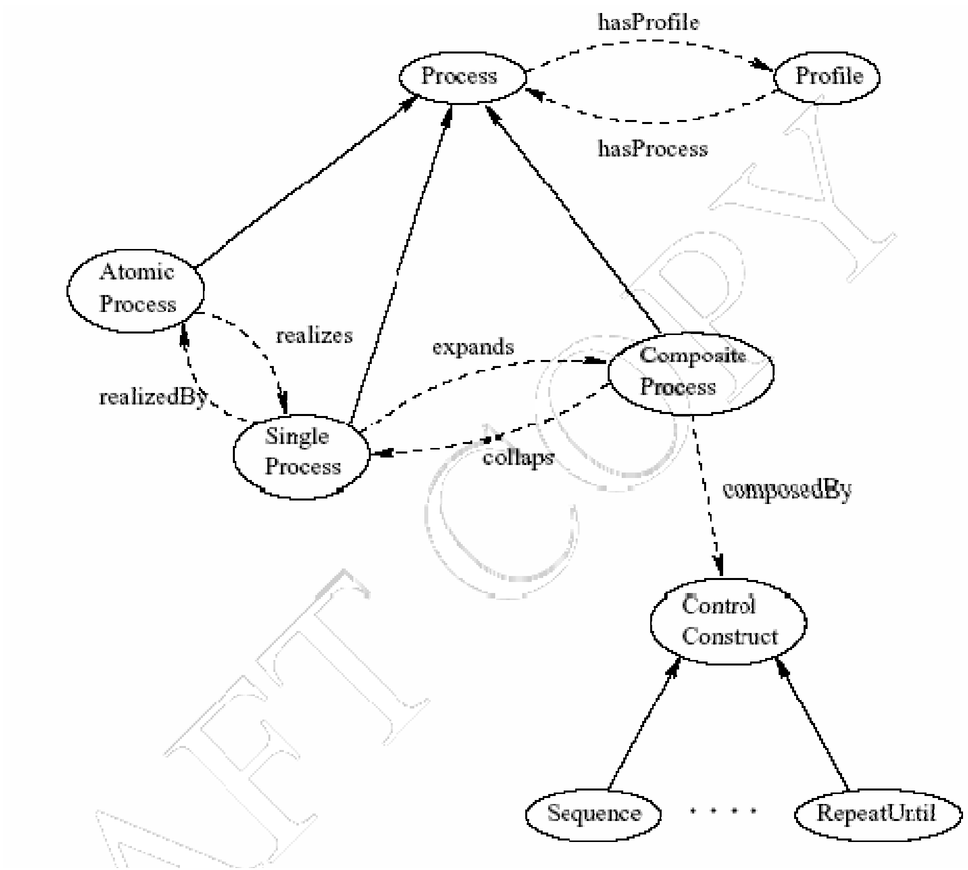
Composition of Processes

- 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

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

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

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

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

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*

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

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