NeOn - Lifecycle Support for Networked Ontologies

Case Studies in the Pharmaceutical Domain

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Agenda

- New Generation Semantic Applications
  - The Need for a Supporting Infrastructure

- The NeOn Toolkit
  - Lifecycle Support for Networked Ontologies

- Applications in the Pharmaceutical Sector
  - Supporting information dissemination about pharmaceutical products
  - Financial transactions with heterogeneous electronic invoices
Semantic Web Research: Putting a conceptual layer over the web
Semantic Web Research: Putting a conceptual layer over the web
Next Generation Semantic Web Applications

Smart Features

NG SW Application

Semantic Web

- Able to exploit the Semantic Web at large
  - Dynamically retrieving the relevant semantic resources
  - Combining several, heterogeneous Ontologies
Key Challenges: large scale, heterogeneous, distributed, contextualized and dynamic semantics

• **Millions** of semantic documents.

• **Hundreds of Millions** of RDF entities.

• **New sources of knowledge** are constantly created.

<table>
<thead>
<tr>
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<th>OWL</th>
<th>OWL Full</th>
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<td>DL</td>
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<td>ALC(D)</td>
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<tr>
<td>ALC</td>
<td>2455 (10%)</td>
<td>ALC</td>
</tr>
<tr>
<td>ALC(D)</td>
<td>293 (&lt;1%)</td>
<td>ALC(F(D)</td>
</tr>
<tr>
<td>ALC(F(D)</td>
<td>105 (&lt;1%)</td>
<td>ALC</td>
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<td>ALC</td>
<td>102 (&lt;1%)</td>
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<td>ALC/D</td>
<td>101 (&lt;1%)</td>
<td>ALC</td>
</tr>
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</table>
Key Challenges: Technological Limitations

- No adequate infrastructure for the whole **application development lifecycle** of the envisaged applications

- Specifically, current infrastructures **not effective**
  - Do not **scale** up
  - Poor support for **rapid development** of large applications by **reuse**
    - Reuse typically so expensive that people prefer to re-build from scratch
    - Problem concerns both the **lack of methodologies** as well as tools/techniques
  - Poor support for **managing the evolution** of an application
  - Poor support for **collaborative development**
  - Limitations of current **user interfaces**
    - E.g., support for navigating several large ontologies at the same time
Funded by EU:
- FP6 Integrated Project under “Semantics-based knowledge and content systems”
- €14.7 mil project budget over 4 years
NeOn: Key Outputs

- **System-level contributions**
  - An open, service-centered *reference architecture* for managing the complete lifecycle of *networked ontologies* and meta-data
  - The *NeOn Toolkit* for ontology engineering and lifecycle management
  - The *NeOn methodology* for ontology and application development

- **Sector-level**
  - Three innovative *case studies* in two sectors

- **Community-level**
  - Creation of an *active community* of users and developers
Networked Ontologies: An Example

Fisheries ontology

- territories
- water areas
- species
- commodities
- vessel types
- gear types

Fisheries networked ontologies

- fish lives in a sea
- synonyms, translations
- commodities from fish
- gear is on vessel
- gear is fished with a gear

Ontologies:
- AgroVoc
The NeOn reference architecture

- **Lifecycle requirements**: Dynamic interaction of **engineering** and **runtime** activities

- **Extensible on all layers of the architecture**
Infrastructure components and tools

- Ontology Storage and Querying (KAON2, Ontobroker)
- Ontology Alignment Management (INRIA’s Alignment server)
- Ontology Registry (Oyster)
- Ontology Search and Exploitation (Watson)
- Ontology Collaborative Design (ontologyDesignPatterns.org)
- …
Highlight: Oyster

- The NeON ontology registry system

- Allows ontology designer to share ontologies by describing their metadata and.…

- … distribute them over a peer-to-peer network
For Oyster to work, there is a need for a common format to be used by peers to represent and exchange information about the registered ontologies.

OMV (the Ontology Metadata Vocabulary) is a machine readable representation of ontology metadata using Semantic Web technologies: it is “an ontology about ontologies”
Watson is a **Gateway to the Semantic Web**

- It collects (through web crawling), analyses, indexes and gives access to semantic information and ontologies on the Web

- At first sight: a **search engine for the Semantic Web**
http://watson.kmi.open.ac.uk
But Watson is more than an interface for users to find, select and explore online ontologies.

It is an infrastructure so that (next generation) Semantic Web application can exploit the Semantic Web as a whole.
A Gateway to the Semantic Web
What is the NeOn Toolkit?

- Reference implementation of the NeOn architecture
  - Support ontology engineering and management
  - Support for complete ontology lifecycle
  - Support for different languages (OWL, F-Logic)
  - Support for networked ontologies (modules, mappings)

- Built on the Eclipse platform

- Extensible architecture
  - Via Eclipse plugin mechanism
  - Via Web Services
Availability

- Basic configuration
  - Completely free
  - Open source

- Extended configuration
  - Commercial version
  - Free for academic use

- Community support
  - For users and developers
  - Tutorials, mailing lists

- Activities coordinated by the NeOn Foundation
  - Opportunity to contribute!

  - Download of the toolkit, plugins, online resources, wiki, …
Plugins Supporting Lifecycle Activities
Plugin Examples

OntoModel: Meta-modeling for ontologies

Radon: Diagnostic and repair for inconsistent networked ontologies

Watson: Reusing knowledge from the Semantic Web

The Alignment Server: Producing and managing ontology alignments
Testbeds

- Managing fishery knowledge to support automatic alert mechanisms
- E-Invoice management in the pharmaceutical sector
- Integration and management of information about pharmaceutical products
The Pharmaceutical Industry provides NeOn with a testbed for Networked Ontologies in several fields of application

- Dynamics of the pharmaceutical supply chain
- Management of nation-wide knowledge on chemist products

Main objectives:

- To facilitate invoice interoperability between organizations exchanging electronic invoices in different formats and models
- Integration and update of heterogeneous, distributed sources of information on chemist products

Semantic nomenclature

Invoice management
The pharmaceutical industry in Europe

<table>
<thead>
<tr>
<th>País/Country</th>
<th>Farmacéutica (mill. €)</th>
<th>Producción per cápita (€)</th>
<th>Producción por empleado (mill. €)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alemania Germany</td>
<td>20.671</td>
<td>250.59</td>
<td>0.18</td>
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<tr>
<td>Austria (1) Austria</td>
<td>1.548</td>
<td>191.42</td>
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<td>Bélgica Belgium</td>
<td>3.814</td>
<td>369.11</td>
<td>0.15</td>
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<td>Dinamarca Denmark</td>
<td>5.334</td>
<td>992.19</td>
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<tr>
<td>España Spain</td>
<td>8.818</td>
<td>210.58</td>
<td>0.23</td>
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<tr>
<td>Finlandia Finland</td>
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<tr>
<td>Francia France</td>
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<td>Grecia (1) Greece</td>
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<td>Holanda Netherlands</td>
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<td>0.36</td>
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<tr>
<td>Irlanda Ireland</td>
<td>16.605</td>
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<td>Italia Italy</td>
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<td>0.21</td>
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<tr>
<td>Portugal Portugal</td>
<td>1.469</td>
<td>141.69</td>
<td>0.13</td>
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<td>Reino Unido United Kingdom</td>
<td>27.144</td>
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<td>Suecia Sweden</td>
<td>5.249</td>
<td>588.12</td>
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</tr>
<tr>
<td>TOTAL UE Total EU</td>
<td>145.359</td>
<td>382.51</td>
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<tr>
<td>Noruega Norway</td>
<td>579</td>
<td>127.59</td>
<td>0.13</td>
</tr>
<tr>
<td>Suiza Switzerland</td>
<td>12.913</td>
<td>1.771.33</td>
<td>0.44 (2)</td>
</tr>
<tr>
<td>Turquía (2) Turkey</td>
<td>2.069</td>
<td>30.16</td>
<td>0.10</td>
</tr>
<tr>
<td>TOTAL EFPIA Total EFPIA</td>
<td>160.920</td>
<td>348.71</td>
<td>0.26</td>
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### Pharmacies and wholesalers in Europe

#### Number of pharmacies in the European Union and other countries

<table>
<thead>
<tr>
<th>País</th>
<th>Número de oficinas de farmacia</th>
<th>Número de habitantes por oficina de farmacia</th>
<th>Indicadores de densidad</th>
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<tr>
<td>Alemania</td>
<td>21,465</td>
<td>3,843</td>
<td>2,6 Farmsacias por 10,000 hab.</td>
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<tr>
<td>Austria</td>
<td>1,971</td>
<td>7,542</td>
<td>1,3 Farmsacias por 10,000 hab.</td>
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<tr>
<td>Bélgica</td>
<td>5,621</td>
<td>1,819</td>
<td>5,5 Farmsacias por 10,000 hab.</td>
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<tr>
<td>Dinamarca</td>
<td>288</td>
<td>18,466</td>
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<tr>
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<td>Finlandia</td>
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<td>6,509</td>
<td>1,5 Farmsacias por 100 km²</td>
</tr>
<tr>
<td>Francia</td>
<td>22,262</td>
<td>2,532</td>
<td>3,9 Farmsacias por 100 km²</td>
</tr>
<tr>
<td>Grecia</td>
<td>8,350</td>
<td>1,934</td>
<td>8,8 Farmsacias por 100 km²</td>
</tr>
<tr>
<td>Holanda</td>
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<td>9,901</td>
<td>1,0 Farmsacias por 100 km²</td>
</tr>
<tr>
<td>Irlanda</td>
<td>1,250</td>
<td>3,146</td>
<td>3,2 Farmsacias por 100 km²</td>
</tr>
<tr>
<td>Italia</td>
<td>16,642</td>
<td>3,485</td>
<td>2,9 Farmsacias por 100 km²</td>
</tr>
<tr>
<td>Portugal</td>
<td>2,476</td>
<td>4,684</td>
<td>2,4 Farmsacias por 100 km²</td>
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<tr>
<td>Reino Unido</td>
<td>12,715</td>
<td>4,889</td>
<td>2,0 Farmsacias por 100 km²</td>
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<tr>
<td>Suecia</td>
<td>900</td>
<td>9,917</td>
<td>1,0 Farmsacias por 100 km²</td>
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<tr>
<td>Noruega</td>
<td>508</td>
<td>8,933</td>
<td>1,1 Farmsacias por 100 km²</td>
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<tr>
<td>Suiza</td>
<td>1,869</td>
<td>4,368</td>
<td>2,3 Farmsacias por 100 km²</td>
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<tr>
<td>Turquía</td>
<td>21,210</td>
<td>3,151</td>
<td>3,2 Farmsacias por 100 km²</td>
</tr>
</tbody>
</table>

(1) Datos correspondientes a 1998.  
(2) Datos correspondientes a 1999.  
(3) Datos correspondientes a 2000.  
Fuentes: Farmaindustria a partir de asociaciones de la industria farmacéutica de cada país, OCDE (Health Data, 2004) e I (Anuario Estadístico, 2004).  
Sources: Farmaindustria estimates based on data supplied by the pharmaceutical industry associations of each country, C (Health Data, 2004) and I (Statistic Annuary, 2004).
Distribution channels of pharma labs in Spain

- **Laboratorios Manufacturers**: 375
- **Mayoristas Wholesalers**: 300
- **Farmacias Pharmacies**: 20000
- **Hospitales Hospitals**: 782
- **Entidades governam. Government agencies**: 1%
- **76%** to **Mayoristas Wholesalers**
- **75%** to **Farmacias Pharmacies**
- **77%** to **Enfermos Patients**
- **20%** to **Hospitales Hospitals**
- **1%** to **Mayoristas Wholesalers**
- **1%** to **Farmacias Pharmacies**
- **22%** to **Enfermos Patients**

Fuente: IMS.  
Source: IMS.
Pharmaceutical laboratories in Spain

Laboratories with proprietary medicinal products by Self-Governing Region
Number of pharmacies: 20,000
Population per pharmacy: 2,000
The Spanish pharmaceutical sector

- 5th largest industry sector in Europe behind car, energy, petrol, and meat

- Main actors in Spain
  - Public administrations
    - Ministry of Health
    - Regional governments
    - AGEMED
  - Laboratories (375)
    - FarmalIndustria
    - PharmalInnova
  - Pharmacies (20000)
    - GSCoP
  - Providers (150)
  - Wholesalers (300)

- Tightly regulated by local and EU directives
Testbed #1: semantic nomenclature (information integration in the pharmaceutical industry)

- **GSCoP**
  - Fax
  - E-mail
  - Docs
  - BOTPlus

- **Labs**
  - Database
  - HTML

- **Other resources**
  - Vademecum
  - Thesauri
  - Taxon
  - Reports
  - Web pages
  - Docs

- **Spanish Pharmaceutical sector**
  - Knowledge intensive
  - Average of 100 new products per month approved, 20 withdrawal and more than 2,500 modified
  - Actors: Governmental bodies, GSCoP, Laboratories, Pharmacies...
  - Complex and heavily regulated

- **Heterogeneous resources**
  - Governmental databases (Digitalis, Integra)
  - BOTPlus
  - Labs info
  - Other resources (regional on-line resources, online Vademecum, international nomenclature)
Semantic Nomenclature
Ontology Network

- Active Ingredient Ontology (ATC)
- Units Ontology
- Location Ontology
- Time Ontology (DAML)
- Laboratory Module
- Ad hoc wrapper
- External Sources

Domain ontologies:
- ATC (WHO) Classification + Spanish extension
- BotPlus Ontology

Application ontologies:
- Digitalis Ontology
- Integra Ontology
- BotPlus Ontology

External Sources:
- INTEGRA Digitalis Ontology
- Unit Standard (Galen)
- Geographical Standard (Simile)
- **Pharmaceutical Reference Ontology**
  - Domain Ontology
  - Represents generic concepts (stakeholders, pharma product, etc.)
  - “Medical_Product” will be the hook (mapped to most of Semantic Nomenclature networked ontologies)
  - Inference and comparison of a product across different classifications (ATC)
ATC Ontology

- Domain Ontology

- Two main branches: ATC description, ATC classification

- “ATC_Classified_Product” that represents all the pharmaceutical products classified through the ATC code

- Two initial levels of ATC code in the hierarchy (therapeutic and pharmacological subgroup)

- Ontology population using R2O / ODEMapster (from Digitalis ATC codes)

- 122 classes, 2 object properties 1 datatype property, more than 2.800 ATC codes -14.000 instances- (>2Mb)
**BOTPlus Ontology**

- Application Ontology
- knowledge represented in the schema of the BOTPlus database
- Classification of pharmaceutical products based on a classification code and the specialty of the product:
  - Human
  - Parapharmacy
  - Vet
  - Medical Herbs
- Ontology population using R2O / ODEMapster (only human and parapharmacy products)
- 37 classes, 12 object properties, 76 datatype properties, more than 30MB of instances
NeOn-powered semantic nomenclature prototype: Online vademecum

Semantic Nomenclature
Web application

Queries

Reference Ontology

Digitalis

BotPlus

GSCoP

WHO

ATC Classification

Government

Consejo General de Colegios Oficiales de Farmacéuticos

Ministerio de Sanidad y Consumo
Value for the pharmaceutical sector

- **Goal**
  - Online vademecum based on networked ontologies

- **Challenges**
  - Heterogeneity of the distributed repositories of drug information
  - Information access integration across the Spanish market

- **Users**
  - Pharmacists (non-ontology experts)

- **Main benefits**
  - Integration of preexisting knowledge resources
  - Agile access to drugs information
  - Reducing latency for information update
Testbed #2: Addressing invoice interoperability in the pharmaceutical industry

- Sharing invoicing models and software platform save costs and reduces complexity
- However, entry barriers are high
Ontologies, users, and standards

“An ontology is a formal, explicit specification of a shared conceptualization”

- Ask the electronic invoicing community: Standards
  - “Standards establish explicit, shared specifications, criteria, processes, or practices”
  - shared = accepted by a community
  - UBL, EDIFACT aspects relevant to invoicing
  - Some ongoing efforts, e.g. UBLOntology (ontolog.cim3.net)

- Ask the user community: PharmaInnova
  - Elicit knowledge from laboratories, providers, pharmacies, and wholesalers
The role of networked ontologies in invoice interoperability

- Networked ontologies provide a **formal model** of the knowledge related with invoicing, which embraces both
  - Current eBusiness standards (EDIFACT, UBL)
  - Sectorial specializations (PharmaInnova)

- Serve as a **semantic gateway** during invoice exchange

- Ensure **consistency** of exchanged invoice data with respect to the formal model of these ontologies

- Provide domain **navigation guidelines** during the process of relating individual invoice representations with each other
Invoicing networked ontologies

More general:

- BPMO
- EO
- TOVE

Business Process

Information Objects

Upper Level

DOLCE Ultralite

IO lite

Time

W3C Time Ontology

Invoicing Reference

XPDL

UBL ontology (SUMO extension)

UBL

EDIFACT

PharmaInnova

PharmaInnova specification

More specific:

Core components

UBL

EDIFACT

Ontology

Standard

Reengineering

Specification
Invoicing networked ontologies (II)

Reference
- Concepts
  - Entity
  - Abstract
  - Event
  - Information Realization
  - Object
    - Agent
    - Currency
      - CurrencyBill
      - CurrencyCoin
  - Physical Object
    - Physical Agent
    - Physical Artifact
    - Physical Body
    - Physical Place
  - Social Object
    - Collection
    - Concept
  - Currency Measure
    - Euro Cent
    - Euro Dollar
    - United States Cent
    - United States Dollar
  - Description
  - Information Object
    - Text Abstract
      - Transaction Entity
        - Standard Transaction
        - Proprietary Transaction
        - Transaction Record ID
    - Code
    - Data Structure
    - Datum
    - Formal Expression
    - Iconic Object
    - Linguistic Object

UBL
- DeliveredToAddress Type
- Jurisdiction Address Type
- Registration Address Type
- SendFromAddress Type
- BusinessIdentification Type
- Card Account Type
- Catalogue Item Identification Type
- Commodity Classification Type
- Contract Type
- Foreign Exchange Contract Type
- Country Type
- Credit Account Type
- Delivery Requirement Type
- Delivery Schedule Type
- Delivery Term Type
- Dispatched Transport Handling Instruction Type
- Destination Country Type
- Exchange Rate Type
- Financial Institution Type
- Hazardous Chemical Type
- Hazardous Transport Type
- Item Measurement Type
- Item Type
- Language Type
- Line Item
- Location Coordinator Type
- Manufacturer's Item Identification Type
- Order Changes
  - Allowance Charge Type
  - Base Price Type
  - Legal Terms Type
  - Tax Amounts Type
- Tax Type
- Ordered Shipment Type
- Origin Country Type
- Package Type
- Actual Package Type

EDIFACT
- Currency Measure
  - non-agreement social object
  - Currency
  - concept
  - description
  - information object
  - EDIFACTInvoice
    - EDIFACTSegment
      - EDIFACTAdditionalInformation
      - EDIFACTAdditionalPriceInformation
      - EDIFACTAdditionalProductID
      - EDIFACTAdjustmentDetails
      - EDIFACTAllowanceCharge
      - EDIFACTBeginningOfMessage
      - EDIFACTCommunicatorContact
      - EDIFACTContractInformation
      - EDIFACTControlTotal
      - EDIFACTCurrencies
      - EDIFACTDangerous Goods
      - EDIFACTDate Time Period
      - EDIFACTDocument Message Details
      - EDIFACTEquipment Details
      - EDIFACTFinancial Institution Information
      - EDIFACTFree Text
      - EDIFACTGoods identity Number
      - EDIFACTItem Description
      - EDIFACTLine Item
      - EDIFACTLocation
      - EDIFACTMeasurements
      - EDIFACTMessage Header
      - EDIFACTMessage Trailer
      - EDIFACTRevenue Amount
      - EDIFACTNameAndAddress
      - EDIFACTPackage
      - EDIFACTPackag eIdentification
      - EDIFACTParts And Instructions
      - EDIFACTPayment Instructions
      - EDIFACTPayment Terms

PharmaInnova
- PharmaInnova
  - "http://pharmainnova.neon.org/##/"
Invoicing networked ontologies: Some figures

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<tr>
<th></th>
<th>Local</th>
<th>Imported</th>
<th>Total</th>
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<td>569</td>
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<td>1</td>
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<tr>
<td>Transitive properties</td>
<td>0</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>
However, users (financial staff) are domain experts that lack any kind of knowledge engineering skills.

Usable tools are required that enable users to work with ontologies.

Users themselves define **mappings** between their invoice representations and a formal model based on networked ontologies.

**Learn by example approach**
- The user annotates a sample electronic invoice with the ontology.
- Annotations define correlations between invoice data and ontology entities.
- All compliant electronic invoices are automatically imported as ontology instances (and then exported to other formats).

Users must work at the **knowledge level**, without caring about how those mappings are implemented and the underlying formalisms.
Application of NeOn technology (ongoing)

- Ontology modularization
- Ontology customization
- Enhanced ontology navigation
- Supporting collaborative processes for the definition of sectorial invoicing models
  - CICERO + WikiFactory
- Evaluation and validation of pharmaceutical ontologies
- Social-oriented analysis of invoicing workflow
Value for the pharmaceutical sector

- Facilitate invoice **interoperability** between organizations exchanging invoices in different formats and models
- Reduce entry barriers in the PharmalInnova cluster
- Enable **users themselves** to define how their invoices should be interpreted

**Expected benefits**
- Save time and effort (hence, money) in the mapping process
- Largely reduce manipulation time per issued invoice
- Reduce the need of engineers and ad-hoc wrapper implementations
- Deal with the invoice data confidentiality issue

**Additionally…**
- To be deployed and evaluated in PharmalInnova in the mid term
- Expected to save additional 30% of current electronic invoice costs

<table>
<thead>
<tr>
<th>Invoices issued</th>
<th>200,000</th>
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<tr>
<td>Invoices received</td>
<td>200,000</td>
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<thead>
<tr>
<th></th>
<th>Current</th>
<th>Digital</th>
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<td><strong>TOTAL COST</strong></td>
<td>851,484.92 €</td>
<td>177,913.64 €</td>
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<tr>
<td><strong>AVERAGE</strong></td>
<td>3.21 €</td>
<td>0.47 €</td>
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NeOn-powered invoice management prototypes

NeOn Toolkit plugin

Standalone application

Web application
Demo outline

1. Annotation phase

2. Import/export phase

3. Pharmacy X

- KIN invoice representation
- Invoices
- ERP KIN

- Provider X invoice representation
- Invoices
- ERP X
Conclusions

- Next generation semantic applications will build on large networks of ontologies.

- NeOn provides an open infrastructure for engineering networked ontologies and building semantic applications:
  - Open reference architecture
  - NeOn Toolkit as reference implementation
  - Opportunity to contribute!

- Example applications:
  - Supporting the dissemination of information about pharmaceutical products
  - Supporting financial transactions based on heterogeneous invoice formats
  - And also: Providing an homogeneous access to information about fisheries activities to monitor and assess the word fish stock
Thank You!

www.neon-project.org
www.neon-toolkit.org

And don’t forget to visit our booth at the exhibition!
Case Study in the Fisheries Domain
Since 1945, FAO collects, analyzes and disseminates information in the area of Food and Agriculture (including Fisheries, Forestry and Natural resources).

The possibility of monitoring fisheries stock depletion has an enormous economic and social impact.
Rationale for Networked Ontologies

- FAO has numerous information systems about the world’s Fisheries:
  - Heterogeneous data:
    • statistics, documents, GIS, thesaurus...
  - Multilingual:
    • Arabic, Chinese, English, French, Spanish and Russian
  - Much of the data are ‘structured’, but not necessarily interoperable.

- FAO’s previous work (2003) to build a Fisheries ontology had drawbacks:
  - too big
  - un-manageable for maintenance
  - inefficient to be used by systems

- NeOn vision:
  - resources remain independent and they are networked by mapping them:
    • smaller ontologies
    • mapping them
    • effective maintenance of ontologies and mappings

Better exploited using ontologies, by bringing together related information
FSDAS requirements:
- Using NeOn Toolkit runtime functionality

Fishery ontologies lifecycle requirements:
- Using NeOn Toolkit design time functionality
Requirements:

- Fisheries ontologies are:
  - medium-to-large multilingual ontologies
  - distributed / networked

- NeOn Toolkit aims to provide support to ontology engineers and subject experts for:
  - modeling, populating, deploying, versioning ontologies
  - keeping them updated through an editorial workflow
  - managing mappings and relations between them
Ontology Conceptualization

The NeOn toolkit provides visualization features helping users editing and understanding models.
Ontology Population

Manual population

Instances migrated to Ontology

Ontology mapped. Instances stay in DB

Instances migrated to Ontology

Ontology mapped. Instances stay in XML
Ontologies Related to Create a Network

- **species**: Common cuttlefish
- **gear**: Traps
- **water areas**: Mediterranean
- **territories**: Spain
- **commodities**: Canned cuttlefish

- **is fished with**: Sepia officinalis
- **lives in**: Mediterranean
- **has shore with**: Spain
- **originates from**: Spain
- **equivalent**: AgroVoc
- **used on**: Trap setters
The FSDAS is a decision support system that will help Fisheries experts analyzing the status and trends of world’s fish stocks.

Requirements (runtime):

- query heterogeneous non-ontological resources
- through
  - the exploitation of the Fisheries networked ontologies
  - integration ontologies
  - runtime components of the NeOn toolkit and infrastructure
- return relevant results to the client
- integrate with advanced annotation and visualization tools
FSDAS Architecture

FSDAS Server

Fisheries networked ontologies

query

mappings

facts from data sources

integrated results

Knowledge bases (metadata, documents, statistics...)

- Time series statistics
- Document Repository
- ASFA abstracts
- GIS data And maps

FSDAS client