NeOn: Lifecycle Support for Networked Ontologies

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D8.6.1 Evaluation of pharmaceutical case studies

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Executive Summary

In this deliverable, we evaluate the outcomes of WP8 electronic invoicing and semantic nomenclature case studies. We aim at measuring the benefits obtained from the application of networked ontologies and NeOn technology into software prototypes and at providing a number of metrics of the impact these developments can have on their respective application environments. For this purpose, we propose a multidimensional approach, which contrasts the final outcomes of the pharmaceutical case studies against our initial expectations. Our approach towards evaluating the results of both case studies spans across a number of dimensions, which range from ontology assessment to user experience, domain coverage, and interoperability performance. As a conclusion to this evaluation, we also present a roadmap describing future uptake of the results in the sector and the strategy required in order to accomplish it.

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1. Introduction

In previous deliverables, we described the application of NeOn technology and methods to the particular case of the pharmaceutical industry, with the twofold objective of demonstrating the benefits that networked ontologies and NeOn technologies can bring into the sector and evaluating such methods and technologies in a concrete and thriving domain like Pharma. Throughout the project, we have pursued this objective, covering a broad spectrum of the key activities in the pharmaceutical sector, incarnated in two different but complementary case studies, respectively about i) maintenance of distributed information repositories on medical drugs and ii) the logistics aspect of the sector, focused on electronic invoice exchange and the heterogeneity problems this represents.

We have created networked ontologies for both case studies, following and contributing to the development of the NeOn methodology, and several prototypes, demonstrating NeOn technology and their application to the industry. In this deliverable, we evaluate our preliminary hypotheses about how NeOn can contribute to improve the pharmaceutical business in the scope of the case studies. We aim at measuring the benefits obtained from the application of networked ontologies and NeOn technology into software prototypes and at providing a number of metrics of the impact these developments can have on their respective application environments.

For this purpose, we propose a multidimensional approach, which contrasts the final outcomes of the pharmaceutical case studies against our initial expectations. Our approach towards evaluating the results of both case studies spans across a number of dimensions, which range from **ontology assessment** to **user experience**, **domain coverage and interoperability performance**, and **expected impact** in the Pharma sector. As a conclusion to this evaluation, we also present a roadmap describing future uptake of the results in the sector and the strategy required in order to accomplish it.

The remainder of this document is structured as follows. Section 2 describes the dimensions chosen and the method followed in order to perform the evaluation of the results from a multidimensional perspective. Section 3 focuses on the evaluation of the electronic invoicing case study throughout the abovementioned four main dimensions. Section 4 analogously applies the same method to evaluate the semantic nomenclature case study. Next, section 5 describes the roadmap for future technology uptake for both case studies in the Pharma sector. Finally, section 6 summarizes the conclusions obtained in the study.

2. Evaluation Method

Figure 1 shows the main dimensions around which this evaluation has been structured. Such structure aims at covering all the relevant aspects in the context of the pharmaceutical case studies, stemming from the development and utilization of networked ontologies and their application into actual software systems with specific requirements, as stated in deliverable D8.1.1 [3] and further developed in the subsequent ontologies and software design and implementation deliverables. Eventually, and for an appropriate dimensioning of the benefits our approach can bring into the pharmaceutical sector, we aim at assessing the effectiveness and efficiency improvements that the tools we have developed based on NeOn technology and methods bring into the relevant scenarios of the sector. Next, we describe the evaluation dimensions.

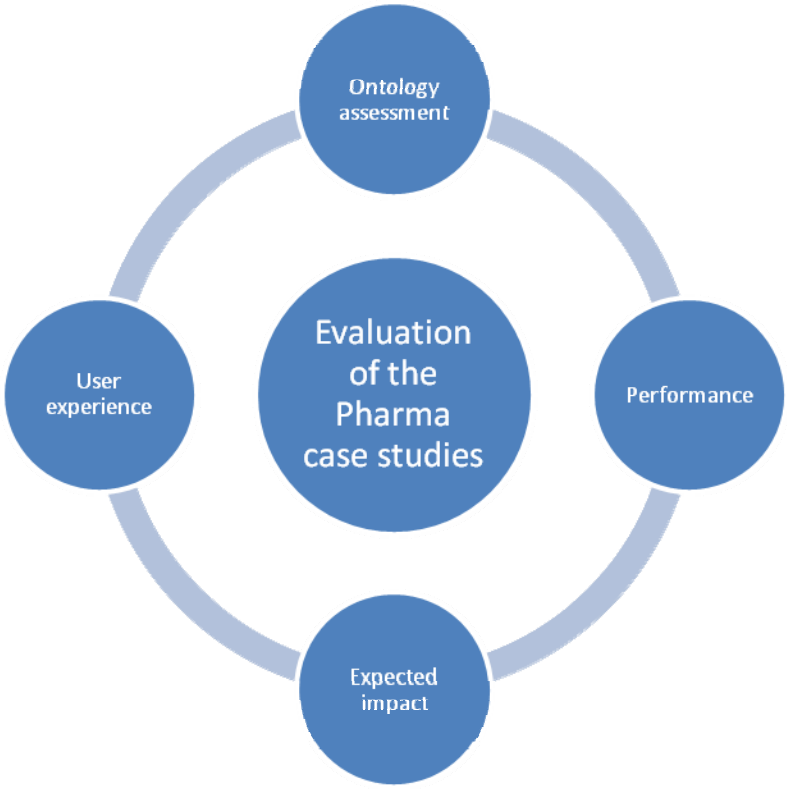

Figure 1: Evaluation dimensions for the pharmaceutical case studies

In our evaluation, the *user experience* and *performance* dimensions are tightly connected with each other in a series of user studies designed and implemented for both pharmaceutical case studies. This has allowed us to measure system performance using evaluation materials previously developed by SMEs themselves during the evaluation of their user experience. For all evaluation dimensions, we have used NeOn toolkit v2.3.0.

2.1 Ontology assessment

The work done in the context of WP8 relies on the assumption that networked ontologies support both our case studies for semantic nomenclature of pharmaceutical data and invoice exchange in a number of

unprecedented ways. Such ultimate benefits can be roughly summarized as: i) facilitating the **integration** and update of heterogeneous, distributed sources of information on chemist products and ii) supporting invoice **interoperability** between organizations exchanging electronic invoices following different formats and models.

A knowledge-based system is just as good as the knowledge resources upon which such a system relies. Therefore, the quality and scope of the ontologies developed for both case studies is the first criterion to consider in our evaluation. NeOn gives us means to ensure ontology quality from different perspectives. First, the NeOn methodology developed in WP5 provides the instruments required to accomplish the ontology engineering tasks comprised by the networked ontology lifecycle. Second, and in a complementary way to the overall methodology, the Ontology Design Patterns[1] (ODP) developed in the context of WP2 contribute both as guidelines for good practice in ontology engineering and also as a quality check mechanism once the ontologies have been produced.

Our ontologies have been developed following the recommendations of both the NeOn methodology and ODPs. Furthermore, for the evaluation aspects addressed in this dimension, we have used ODP to ensure that our ontologies are well formed, correct, and follow the design principles recommended by NeOn. As a consequence of this exercise, a number of improvements have been proposed and the ontologies updated. Additionally, the size and complexity of some of our ontologies make it advisable to explore, and implement where necessary, the convenience of producing ontology modules (through the NTK Modularization plugin) out of them which focus on certain parts of the domain, with the goal of increasing reusability and sharing.

2.2 User experience

The software systems developed in the context of the pharmaceutical case studies aim at alleviating the knowledge-intensive tasks that domain experts need to accomplish through the different aspects of the pharmaceutical domain. At this point, it is convenient to recall that our users are non-ontologists exclusively i.e. they do not have any background related with ontologies either from an engineering perspective or as mere beneficiaries of the technology. Therefore, our aim has been to provide them with tools that benefit from the utilization of networked ontologies but which at the same time abstract final users from any complexity stemming from ontology engineering or related tasks.

This evaluation dimension aims at assessing the extent to which this goal has been achieved by our tools. We have organized a number of user studies inspired by those performed in WP4 [5] [6] aiming at measuring the effectiveness and efficiency increase provided by the tools. These user studies have been complemented with methodological approaches like those proposed in Brooke's System Usability Scale (SUS). [1] The parameters subject to study include the usability of the tools developed in the pharmaceutical case studies, their ease of use, and their intuitiveness. The evaluation of this dimension concludes with an analysis of the learning curve required by the users to master our tools. Next, we illustrate the evaluation method followed for this dimension in both case studies.

[1] http://ontologydesignpatterns.org

User experience evaluation in the invoicing case study

The evaluation was performed in the context of a user study developed at Kin Laboratories in December 2009, where the users involved completed a number of tasks with the i2Ont system, including the following tasks:

- Loading of invoices into the system,
- Annotation of a sample invoice against the invoicing ontologies in order to teach the system in automatically importing and exporting all subsequent invoices compliant with it,
- Actual invoice import and invoice export.

Two facilitators participated in the user study, one from Kin Laboratories and another one from iSOCO, who supervised each user groups formed by two individuals. This proved to be useful in order to both support users in need of assistance and to continue with the tasks assigned to each user. An additional outcome of the annotation task is the configuration files produced by the users, which we have later on utilized for the evaluation of the performance dimension, where the invoice transformation capabilities of i2Ont have been measured.

The users selected for the evaluation are experts in financial and administration tasks from Kin's finance staff, with knowledge in electronic invoicing, especially with the PharmaInnova platform.[2] Such users, from now on subject matter expert (SME), were classified in four main groups, as shown in Table 1.

SME group	Description
SME 1	Accountants specialized in processing invoices issued by providers, which need to be either accepted or rejected by the laboratory
SME 2	Accountants specialized in processing invoices issued to clients of the laboratory, including pharmacies and public administration
SME 3	Chief of commercial finances, in charge of supervising the economic transactions between the laboratory and both clients and providers
SME 4	Chief of commercial finances for clients, reporting to the chief of commercial finances and responsible for economic transactions with the clients of the laboratory

Table 1: User groups participating in the evaluation of the user dimension

[2] http://www.pharmainnova.com

The most relevant task (see point 4 below) for the purpose of i2Ont focused on evaluating the process of configuring the system for automatically importing and exporting electronic invoices in and out of the invoicing ontology network. This process, first described in D8.4.1, consists of the annotation against the invoicing ontology network of a representative sample invoice by SMEs. During the annotation process, i2Ont learns the correspondences between invoice data compliant with such a format and model and the ontologies. This serves a twofold purpose: i) it exploits SMEs' knowledge about the invoicing domain to map invoice data against a formal model and ii) it enables i2Ont to produce a configuration record, defining such correspondences for this particular case.

It is worthwhile recalling that this mechanism is especially useful in cases where the schema followed by the invoice data is unknown, it has not been formally defined, or when the organization owning such data does not wish to release information about it. All such eventualities are relatively frequent in the context of PharmaInnova, the cluster of pharmaceutical laboratories, and its relationship with clients and providers. Our main hypothesis about this annotation process is that the system is usable and intuitive enough for the average SME to produce the annotations corresponding to all the relevant data for an invoice format and model with minimal training and, once trained, mainly unsupervised.

The user study was scheduled with the following agenda:

1. Introduction to NeOn, where participants were briefed about networked ontologies and the vision of NeOn.
2. The i2Ont NeOn-enabled invoice technology, a description and tutorial of the tool that the participant SMEs would use in the following.
3. Objectives of the user study, both for training and evaluation of i2Ont.
4. Main task. Annotation of sample invoices by the different SMEs to produce different configuration files for invoice import/export. Each SME annotated two different sample invoices using i2Ont. The facilitators measured their performance in completing the task and the number and nature of the assistance required. This data has been used to produce a profile of the evolution of the skills of SMEs and their mastering of i2Ont.
5. Post-user study, where SMEs filled in a questionnaire collecting their input about i2Ont in terms of usability and hands-on experience (effectiveness and efficiency). The relevance of the information collected depending on the expertise of each SME with related tools. For this purpose, the questionnaire also collects information about user profile. The complete questionnaire can be found in Appendix A.

The main goal of this evaluation activity is to collect information from SMEs about the usefulness of the tool and its usability. The conclusions drafted from this exercise have been useful to detect those aspects which hamper user interaction with i2Ont, especially. We have built on such conclusions in order to improve the final version of the system by applying the suggested enhancements. The final version of i2Ont has been integrated with the PharmaInnova invoicing platform (PharmaInvoicing) in the form of a web application, a pre-production environment before actually reaching the market.

User experience evaluation in the semantic nomenclature case study

The evaluation was carried out involving domain experts from the medical domain from outside the project in two sessions: the first one in January 2010 with ATOS eHealth experts, and the second in February 2010 with a group of people from hospitals, academia and other domain experts. At this point it is important to recall that the Semantic Nomenclature case study does not have any user partner inside the project. For this reason the evaluation sessions were preceded by a training session. The facilitator showed the usage of the NeOn Toolkit plus some of the most useful plugins for the tasks at hand, and explained how to use the Semantic Nomenclature Web application. The users were asked to perform several tasks:

- Use the NeOn Toolkit and some plugins to browse, revise and make slight changes to the Nomenclature ontologies.
- Upload the ontologies to the Cupboard Semantic Nomenclature space.
- Use the Semantic Nomenclature application.

The methodology was similar to the one used in the invoice case study, and it is based on previous user evaluations carried out in WP4 and WP9. Two facilitators from ATOS participated in the user study, who supervised and helped each user group formed by four individuals. The facilitators also took notes about the users' comments, helping gather qualitative data for the evaluation.

In general, the users of the first evaluation session were domain experts with little experience in ontology engineering, but good knowledge about the domain. The users of the second session were more heterogeneous, having, in general, a better knowledge and even experience with other ontology engineering tools. We divided the users in two groups, basically domain experts with no knowledge about ontologies, and experts with some experience in ontology engineering, namely **Group1** and **Group2** from now on. In the first session, all users (4) were under the Group1, and in the users were divided in the two groups, one facilitator assisting each of the groups.

The user studies were scheduled with the following agenda:

1. Training session. Including training about NeOn, NeOn Toolkit, some of the plugins and the case study objectives and take.
2. Facilitators exercises. The facilitators made a tour showing the main Semantic Nomenclature features both using the NeOn Toolkit and the Web application.
3. User study. The users were asked to:
    a. Use the NeOn toolkit to perform some guided experimentation:
        i. Visualise the ontologies in the NeOn Toolkit using the core functionalities and several visualization plugins.
        ii. Perform and review alignments between the Digitalis and BotPlus ontologies using the alignment server.
        iii. Experiments for ontology modularization.

iv. Upload changes to the Cupboard.

b. Use the Web application:

i. Search a specific drug in the Digitalis ontology.

ii. Look for related drugs and knowledge in other ontologies from the network.

iii. Locate related drugs using the Linked Data module.

4. Post-user study. The users where asked to fill in a questionnaire collecting their input about the experiment. The questionnaire can be found in Appendix B.

The goal of this evaluation is twofold. On the one hand, we pursued collecting information from the users about the usefulness of the NeOn Toolkit and the Nomenclature Web application and its usability. On the other hand, we tried to assess the convenience of the Semantic Nomenclature approach to map drug ontologies. The conclusions from the exercises were taken into account during the last period of the project to further improve both the ontologies and the Web application.

2.3 Performance

Through this evaluation dimension, we measure the systems against their functional requirements and ultimately assess whether they effectively cover the purpose for which they were designed and implemented i.e. to contribute to solving the interoperability problem during invoice exchange between distributed organizations and to provide unified access to previously dispersed drug information, respectively. Next, we describe the method applied to measure this dimension in the two case studies.

Performance evaluation method for the invoicing case study

The main functionalities of i2Ont deal with i) providing SMEs with the means needed to use their own knowledge and expertise in order to define themselves the correspondences between their invoice data and a formal (ontological) model and ii) once these mappings have been defined, use them to support the automatic exchange of electronic invoices between organizations, transparently from their original formats and models. The invoicing lifecycle supported by i2Ont through those two functionalities is illustrated in Figure 2 (more details can be found in D8.4.1 [5] and D8.4.2 [6]), where SMEs first define the mappings and then i2Ont uses such information to import invoice data into the ontology network and export it from there to the format and model of the receiving entity. We have measured i2Ont's performance with respect to both functionalities as follows.

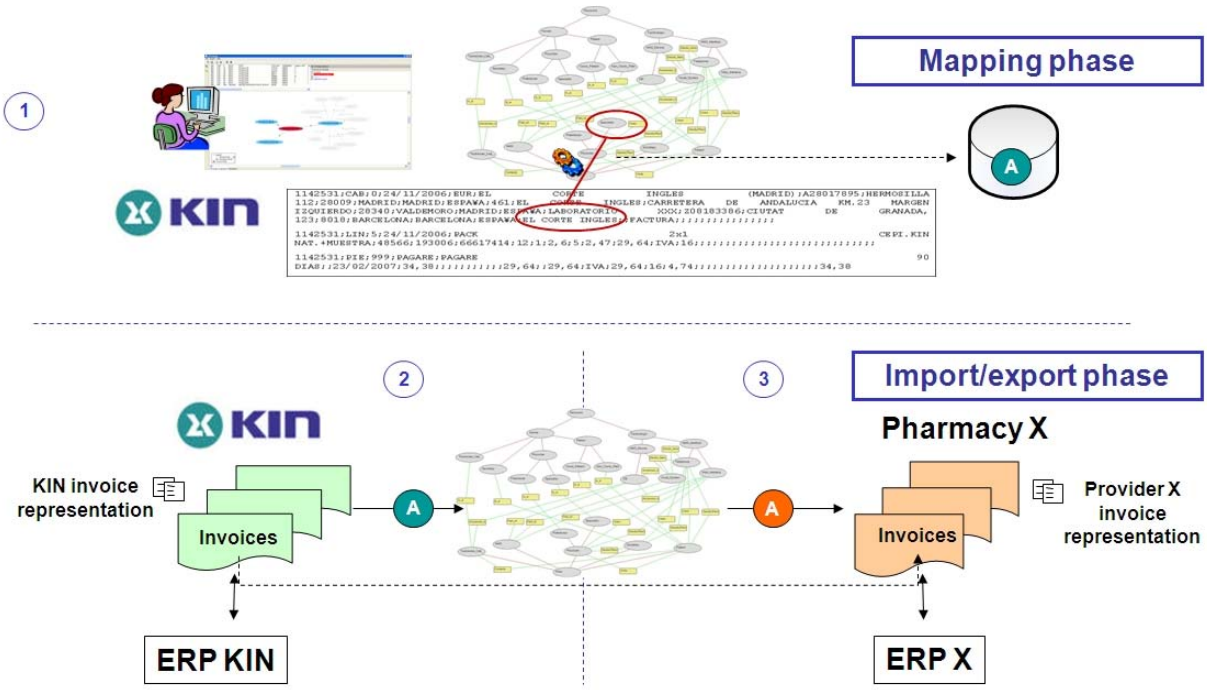

Figure 2: i2Ont two-phased invoice lifecycle

Coverage of SME-defined mappings between invoice data and the invoicing ontologies

Evaluating the system with respect to the first functionality requires measuring the coverage provided by the mappings produced by SMEs between invoice data and ontology entities. Good coverage results shall confirm the following two hypotheses. First, if SMEs can effectively use i2Ont to produce high quality mappings between invoice data and the electronic invoicing ontology network, automatic invoice transformation between diverse invoice formats and models will be possible and of high quality. Second, SMEs will be able to define such mappings in an almost unsupervised manner, thus saving costs in terms of additional developments and time of specialized software engineers.

As part of the user study, we aim at assessing whether or not the required mappings between all the relevant pieces of invoice data and the invoicing ontology network (see Figure 3. More detail can be found in D8.3.1 [9] and D8.3.2 [10]) have been correctly defined by SMEs. Invoice interoperability i.e. actual transformation requires coverage to tend to 100% in order to avoid erroneous data exchange or missing invoicing data.

The task proposed to the participating SMEs requires each of them to browse the ontology network in order to map each of the relevant invoice data fields against the appropriate data property. Each SME will accomplish this task with two sample invoices which will provide us with a notion of how SMEs improve in their expertise with the tool as they use it. During the realization of the task by the SMEs, we will focus on the following measures:

1. **The quality of the mappings** defined by the SMEs, in order to confirm our hypothesis that i2Ont provides SMEs with the necessary support to express the mappings. We estimate the quality of the mappings through a measure of the average coverage errors, according to:

   $$Average\ coverage\ error = \frac{\sum_{i=1}^{n} e_i}{n \cdot m_f}$$

   Here:

   - e_i = number of erroneous mappings per invoice and SME.
   - n = number of SMEs.
   - m_f = number of invoice fields to be mapped.

2. **The learning curve of the SMEs** in order to master i2Ont. This will help us evaluate the evolution of SMEs in the utilization of i2Ont and identify bottlenecks upon interaction with the system. Ultimately, the analysis of this measure will provide us information on the effectiveness and efficiency of i2Ont and the effort required by SMEs to use the tool. We will estimate the learning curve through the average accumulated number of correct mappings with respect to time.

3. **The degree of assistance required by SMEs** in order to operate with i2Ont. This measure is directly related with the learning curve and has a clear influence on the overall quality of the mappings. An excessively large amount of help required by SMEs from the facilitators of the task would indicate a lack of skills to accomplish the task on their own. We will take two different measures in this aspect. First, we will calculate the average percentage of mappings where SMEs needed some kind of help from the facilitators and, second, we will compare the figures obtained for each of the two sample invoices.

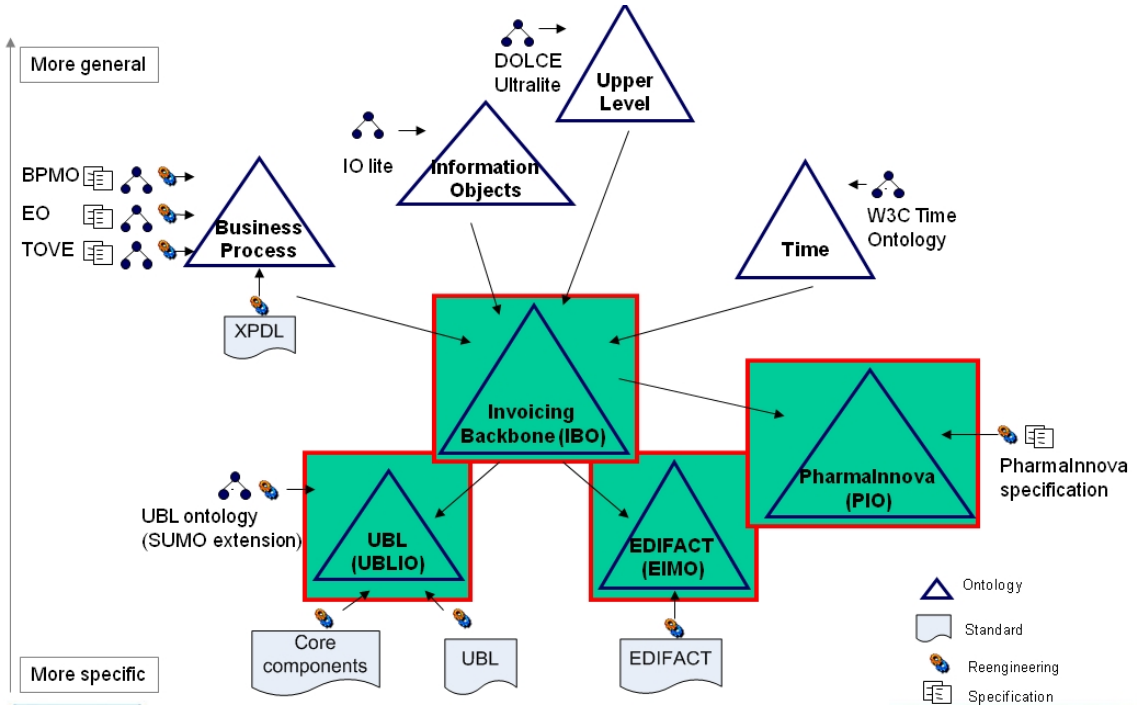

Figure 3: Electronic invoicing ontology network

The results of this task will be graphically shown according to the three different but complementary perspectives described above. In order to compile the required data, during the exercise we will collect samples of the progress of each SME in intervals of 5 minutes. We will annotate the number of mappings accomplished during that time and those in which SMEs need support from the facilitator. From these, we will estimate the learning curve of the SMEs and the degree of assistance required. Finally, we will calculate the average mapping coverage achieved by the different SMEs.

Interoperability support for automated invoice exchange

The objective of this part of i2Ont's performance evaluation is twofold. First, we aim at assessing the reliability of the system in importing and exporting large volumes of invoice data, in circumstances similar to those potentially occurring in an exploitation scenario. Second, we analyze non-functional data stemming from this process, fundamentally the time required to import and export a large pool of invoices. This will help us identify potential performance problems and refine the system.

The mappings produced by SMEs during the previous task (see Appendix A), have been used in order to check i2Ont's capabilities to automatically transform invoice data from the format and model of invoice emitters to those of receivers. In order to check i2Ont's performance in invoice exchange, we have taken a set of 10,200 invoices compliant with the first sample invoice used during the previous phase of the performance evaluation and have used i2Ont to first import them into the ontology network and then export the resulting instances into the format and model exemplified by the second sample invoice.

Therefore, we will evaluate the quality of i2Ont in terms of its capabilities for invoice interoperability and the time required in the following operations:

- Import of electronic invoice data as instances of the invoicing ontology network.
- Export of electronic invoice data, from instances of the invoicing ontology network into the selected format and model.

We will run these interoperability tests in a PC with 2 GBytes of RAM and a 2.16GHz processor, running Windows XP Professional SP3. We will issue invoices compliant with the first sample invoice in sets of 300 for i2Ont to import them into the invoicing ontology network and then export them into the format and model specified for the second sample invoice. For each invoice, we measure the quality of the import/export i.e. every relevant piece of data has been transferred and this has been done as specified during the mapping phase. We also record the time required to load the invoice, import it, export it and save it. Finally, we calculate the average measures for the 34 invoice sets.

Performance evaluation method for the semantic nomenclature case study

Due to the specific nature and goals of the Semantic Nomenclature, performance is not as strong a requirement as in the Invoice Management case study. This is due to the fact that the Semantic Nomenclature aims towards showing the feasibility of establishing and exploiting mappings between different drug terminologies and ontologies, and not actually deploying the solution in a specific partner client. Hence performance evaluation has been done in a more qualitative way.

The most important measures for our case study revolve around the usage of ontologies for the health domain for the description of drugs, and in particular to explore means of alignment of different terminologies and further applications on top of the ontology network. In this sense the qualitative assessment done is based on evaluating the following items:

1. Usage of medical ontologies within the NeOn Toolkit
2. Establishing alignments between ontologies representing drug descriptions
3. Usage of the Semantic Nomenclature Web application

The methodology to assess these four items will be based on the facilitators' observation of the people using the tools during the two evaluation sessions. Part of the evaluation questionnaire shown in the Appendix B has some specific questions targeting this performance evaluation. This questionnaire will be filled in by the participants on the two sessions. The results of this task will be shown in section 4.3.

2.4 Expected impact in the pharmaceutical sector

As introduced earlier, the two case studies deal with different but complementary aspects of the pharmaceutical domain, which increases chances for impact in the sector. In the case of the invoicing case study, a considerable economic impact is expected upon commercial uptake, with 30% savings with respect

to current electronic invoicing systems and ERPs. Thus, from an average cost of 0.67 EUR per electronic invoice, the utilization of i2Ont could revert into a cost of 0.47 EUR for those organizations taking up the technology. Additional benefits of adopting i2Ont include: saving time and effort in developing the required facilities to import and export invoice data, reducing manipulation time per issued invoice, and reducing the need of external consultants specializing in invoicing technology and the different market solutions. In the case of the semantic nomenclature case study the main goal is to be a showcase of the way NeOn can help to overcome the difficulties of mapping and managing complex ontologies about drug description in the health domain. In this sense the exploitation of the results of the case study cannot be measured directly in terms of cost reduction. However, we expect NeOn to have an impact in this domain. In particular, during the project life-span we have contacted several institutions and public organizations that are very much in favour of using NeOn technology and the semantic nomenclature approach to describe their information and map it to other international ontologies.

Nevertheless, in order to transform such notions of expected impact into a reality, we include in this document (section 5) a roadmap to be executed by the agents in charge of transferring this technology to the market. In the case of the invoicing case study, such a roadmap is already part of PharmaInnova's agenda for the development of the platform and includes a number of short-mid term actions to deploy i2Ont into the production line and provide their users with its functionalities.

3. Evaluation of the invoicing case study

Next, we go through each of the evaluation dimensions in order to present the results obtained from executing the evaluation method described in section 2 for the outcomes of the invoicing case study.

3.1 Ontology assessment

Though a deeper description can be found in previous deliverables, we will first quickly introduce the invoicing ontology network. As shown in Figure 3, the invoicing ontology network comprises a number of ontologies including the Invoicing Backbone Ontology (IBO) and a number of ontologies for each of the subdomains addressed in the invoicing case study. Such ontologies are the UBL Invoicing Ontology (UBLIO) for the UBL eBusiness standard, the EDIFACT Invoice Message Ontology (EIMO), which represents the part of the EDIFACT standard describing the messages used for invoice exchange, and the PharmaInnova Ontology (PIO), which provides a semantic description of the invoicing model used in the PharmaInnova platform.

The aggregation of all these ontologies into a single one results in the Aggregated Invoice Ontology (AIO). AIO is a considerably large ontology, with approximately 600 classes, 60 datatype properties, 200 functional properties, and 500 object properties.

IBO has been built through the aggregation of a number of business process ontologies, like the Enterprise Ontology [12] and TOVE[3], time ontologies, like the W3C time and time zone ontologies, and upper-level ontologies, like DOLCE Ultralite and the Information Objects (IO) ontology[4]. While UBLIO is an extension of the UBL ontology[5], based on SUMO, and the Core Components[6] recommended by the standard, EIMO is the ontological version of the EDIFACT [7] specification for invoice exchange. Finally, PIO has been produced by reengineering the PharmaInnova XML schema describing the invoicing model adopted by the cluster into an actual ontology.

The analysis of the invoicing ontology network drew a number of conclusions and suggested improvements deriving into concrete actions, which we summarize here in six main categories:

1. **Ontology documentation** was missing for some ontology entities. Especially in the case of the most relevant ontology entities, we have added *rdfs:comment* annotations describing them. Additionally, the ontologies in the ontology network itself were not documented. Altogether, this could have hampered reuse and the indexing of the ontologies by ontology search engines like Watson.
2. **Missing range and domain in some object properties.** While a reasoner would simply put *owl:Thing* by default, certain editors do not provide some services by default in absence of a domain

[3] http://www.eil.utoronto.ca/Enterprise-modelling/tove

[4] http://www.loa-cnr.it/DOLCE.html

[5] http://ontolog.cim3.net/cgi-bin/wiki.pl?CctRepresentation

[6] http://ubl.xml.org/tags/core-components

or range. In order to make up for this eventuality, we have put *owl:Thing* where domain or range was missing. However, some properties intuitively have a name that would suggest a more specific domain or range, like 'tax'; in those cases, a more specific characterization has been pursued.

3. **AIO is too monolithic.** A partition of AIO performed with NTK's partition tool shed a total of 13 possible modules stemming from it (see Figure 4). The most general architectural issue is that a large part of the ontology contains a process ontology, which can be self-contained and imported. Other modules deal with calculations, taxes, some information-related notions, and finally with invoices and transactions. We have implemented a modularization of the ontology into such modules in order to make understanding and management of the ontology more intuitive.

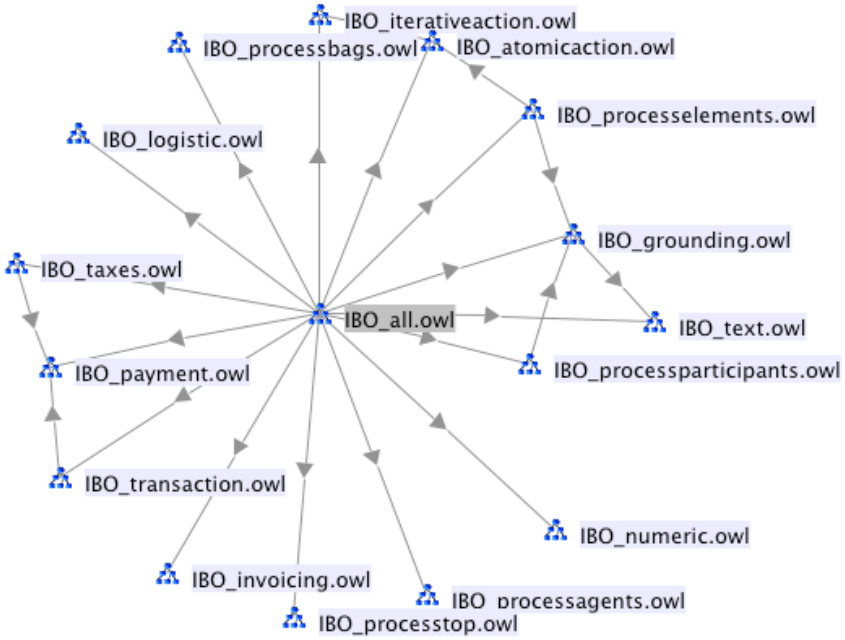

Figure 4: AIO's import graph

4. **Some properties were not used.** This is, for example, the case of the property *institutionIdentifier* which, since it had no usage or axiom, made it hard to detect any thematic property that could be used to collect it. Unused properties have been removed.

5. **A redundant time ontology was reused.** Three time ontologies were reused: the W3C time ontology (only for the class *TimeInterval*), the W3C time zone ontology (only for the class *TimeZone*), and an additional time ontology, which had been engineered specifically for this case. A more thorough analysis has shown that such an ontology is redundant with respect to the other two and it has therefore been removed.

6. **Ontology Design Patterns.** Some possible new uses of ODPs have been identified. First, each of the classes aligned to *dul:Process* or *dul:Relation* could be extracted as individual modules (together with their relevant properties and axioms), and designed as specializations of the Situation

pattern.[7] Second, there are some properties, such as *minFn* or *lessThan*, tailored to make calculations and to state numerical ratios, whose domain and range is on classes, rather than datatypes. This suggests the utilization of patterns such as *ParameterRegion*.[8]

Furthermore, other improvements have been made to the invoicing ontologies. The version and namespace of the upper-level ontologies *DUL.owl* and *IOLite.owl* have been updated to their current one. As a consequence, some properties have also been updated. For example, *dul:SocialAttribute* has been updated to *dul:SocialObjectAttribute* (name has changed in the latest versions of DOLCE+DnS). Quantity-oriented properties have been moved under *numericProperty* for improving clarity of relation space. In order to make properties more easily retrievable and to prepare possible pattern-based design evolution, they have been collected under a few 'thematic' properties like *invoiceRelation*, *invoiceAttribute*, *numericProperty*, *processRelation*, and *quantityRelation*. Finally, the spelling of some property names like *AbsoluteValueFn* and *SubtractionFn* has been corrected.

3.2 User experience

As introduced in section 2, we classify the information drawn from the user study into a number of main categories in order to evaluate i2Ont from the perspective and experience of SMEs during system interaction. Such categories are: user profile, usability, effectiveness and efficiency, and usefulness. Next, we describe our findings for each of them.

User profile

A characterization of the kind of SMEs using i2Ont and their expertise is required for a twofold reason: i) to benefit from the real-life sample of SMEs participating in the user study through the analysis of their skills and needs, and checking the conclusions of such analysis against the original assumptions we drew from the requirements phase, ii) to prioritize the different aspects of the tool in terms of their potential impact in the user population e.g. in case of SMEs largely unskilled in IT and knowledge-intensive systems, usability is probably the main entry barrier to the tool beyond its actual usefulness and should be taken specially into account.

We were particularly focused on two main aspects of our SMEs' profiles: their familiarity with ontologies and ontology engineering tools and their experience with electronic invoicing technology and the models used in the industry to represent invoicing data. As anticipated, none of the SMEs, regardless of their position in the company or track record, had previous experience with ontologies and ontology engineering tools (Figure 5). This implies that it is especially relevant for i2Ont to be able to abstract SMEs from any ontology engineering task, providing them with means that allow them to take advantage of the expressive power, domain

[7] http://ontologydesignpatterns.org/cp/owl/situation.owl

[8] http://ontologydesignpatterns.org/cp/owl/parameterregion.owl

formalization and representation capabilities, etc. of ontologies without actually perceiving their existence. This also implies that usability and visualization skills are key for this group of SMEs.

Interestingly enough, though completely illiterate in ontology engineering, our SMEs are very knowledgeable of electronic invoicing technology, especially of the platform and models used in the context of PharmaInnova (Figure 6). This will help us check the correction and completion of the representation of the invoicing domain contained in our ontologies and the usefulness of i2Ont in order to address the interoperability problem in invoice exchange.

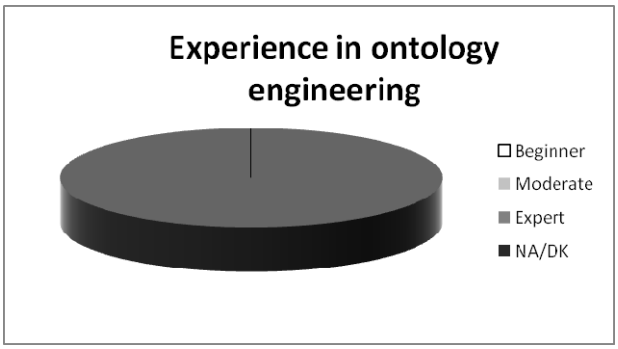

Figure 5: Experience in ontology engineering

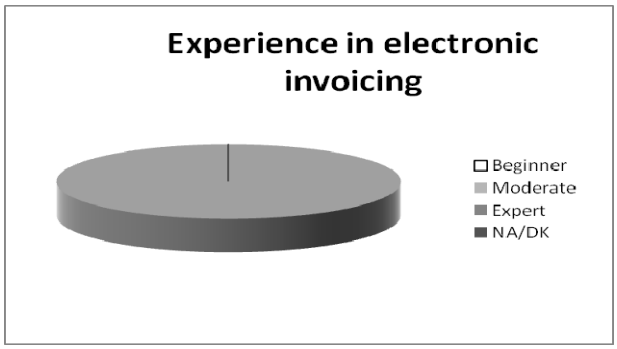

Figure 6: Experience in electronic invoicing

Usability

As anticipated by the user profile of our SMEs, usability is one of the key features for i2Ont. In general, our SMEs found it quite straightforward to get acquainted with the tool (Figure 7). Additionally, most of them found the tool extremely clear and simple to use (Figure 8).

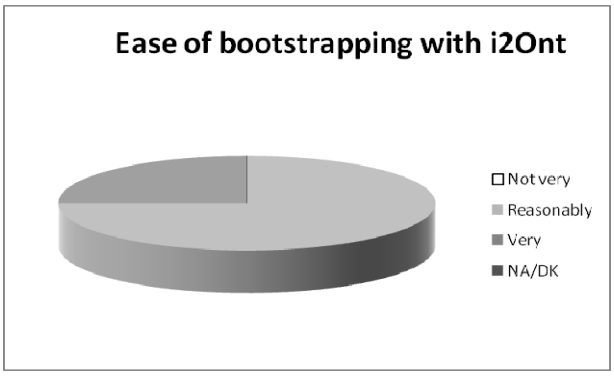

Figure 7: Ease of bootstrapping with i2Ont

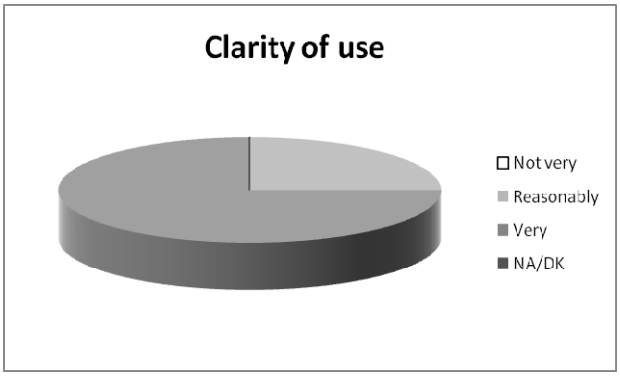

Figure 8: Clarity of use

We have also polled SMEs for their impressions on the documentation and interactive help functionalities provided by the system, the graphic design, and its user interface. SMEs curiously made hardly any use of i2Ont's user documentation at all. Thus, when queried about it they had problems in actually qualifying it as useful or not (Figure 9).

Considering the advanced level to which they fulfilled their tasks, this can be interpreted as a good sign about the usability of the tool. SMEs did not need to check the user documentation to address their assignments. Thus, i2Ont proved to be usable enough for SMEs to make their work without needing additional support. This conclusion is extensive to the quality of the user interface. 75% SMEs considered it was neatly designed and appropriate for the tasks at hand (Figure 10), though 25% missed a more extensive use of tooltips throughout the system.

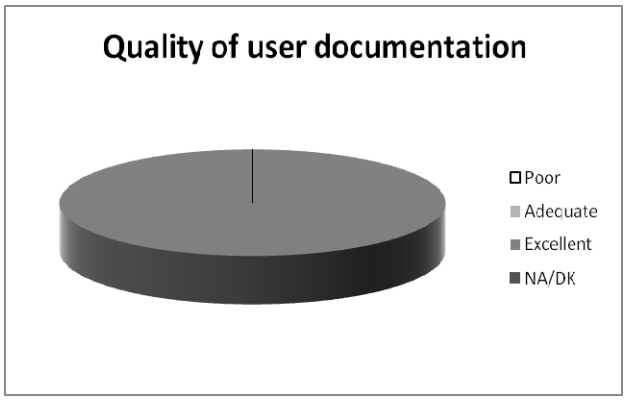

Figure 9: Quality of user documentation

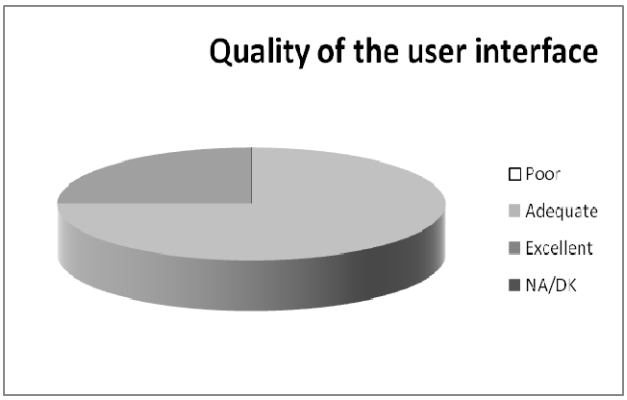

Figure 10: Quality of the user interface

Effectiveness and efficiency

In general, all participant SMEs rated the behaviour of i2Ont as adequate. None of them complained about annoying features or repetitive actions, providing high rates for effectiveness and efficiency.

During the user study, we also measured the quality of the invoicing ontology network, based on our SMEs' knowledge of the domain. They could assess the coverage of the domain by visualizing and browsing the ontologies with the Relationship Visualizer plugin, integrated in i2Ont.

From this exercise, we drew two main conclusions. First, 75% SMEs rated the coverage of the domain as adequate, while 25% proposed modifications, some of them finally included into the ontologies. Second, the domain visualization metaphor proposed by Relationship Visualizer proved to be excellent according to 75% of the SMEs for the purpose of i2Ont, while 25% considered it adequate.

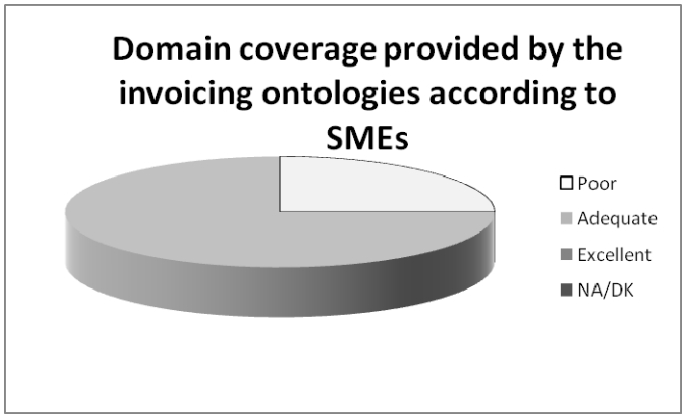

Figure 11: Domain coverage provided by the invoicing ontologies according to SMEs

An analogous result was obtained when questioning SMEs about the mixed navigation approach based on both taxonomies and relations. 25% of SMEs considered it as extremely adequate for the main task of i2Ont, while 75% showed themselves satisfied with it. Thus, we concluded that Relationship Browser[9] proposes an ontology visualization and navigation method that favours the task of mapping data, especially invoice data, against a formal model and increases user effectiveness during such task.

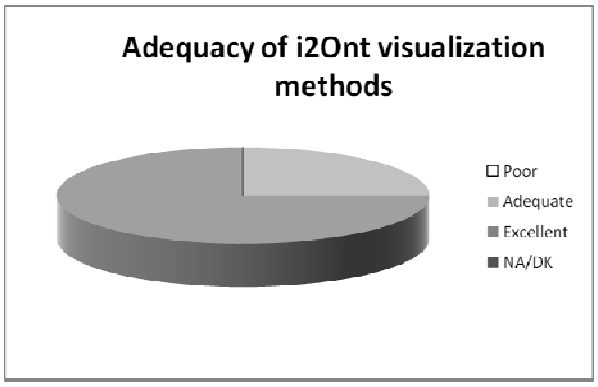

Figure 12: Adequacy of i2Ont visualization methods

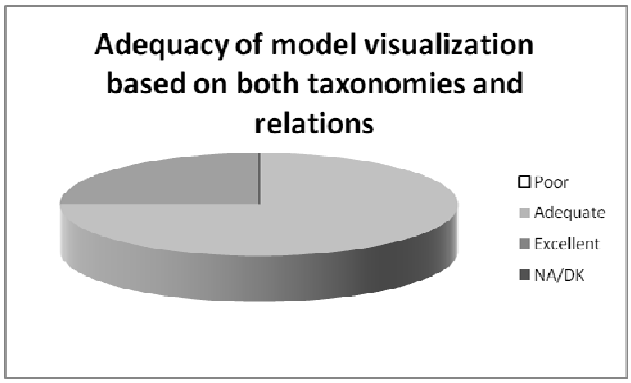

Figure 13: Adequacy of model visualization based on both taxonomies and relations

Usefulness

We analyze the usefulness of the tool in terms of the main task accomplished during the user study i.e. using the tool to map two different sample invoices against the formal model provided by the invoicing ontologies. We understand the previous categories of the user study as necessary (but not sufficient) conditions for this one. Thus, if i2Ont were not deemed by SMEs as usable and effective for the relevant user profiles, it could

[9] http://www.neon-toolkit.org/wiki/Relationship_Browser

never be useful. In order to confirm whether SMEs find i2Ont useful, we directly asked them about their impressions (Figure 14).

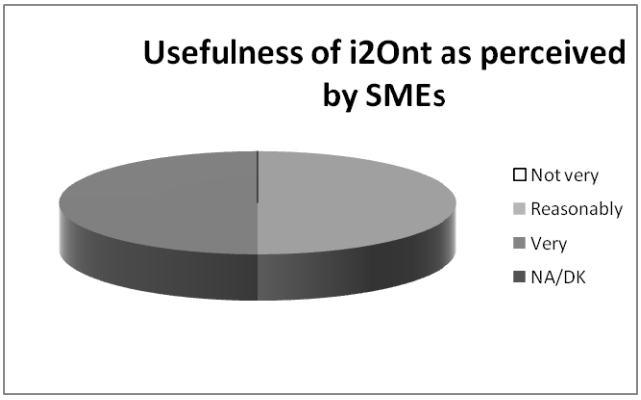

Figure 14: Usefulness of i2Ont as perceived by SMEs

The results show that half of the polled SMEs consider that i2Ont is a very useful tool. However, it is also worth highlighting that the other half did not feel they had enough information to answer the question. The rationale behind this apparently contradictory result is that, once the mappings have been defined, SMEs also need to check the outcome of applying them to actual import and export of invoice data in order to assess the overall usefulness of the tool.

The next section completes these results with the conclusions drawn from the performance evaluation of i2Ont. In this evaluation, the mappings obtained during the user study were actually used to import 10,000 invoices compliant with the first sample invoice and then export them into the format exemplified by the second sample invoice.

3.3 Performance

Next, we present the results of the evaluation of the two sub-dimensions corresponding to the performance evaluation category: the coverage of invoice data achieved through the mappings defined by the SMEs and the support for invoice exchange actually provided by i2Ont with those mappings.

In order to measure the first sub-dimension, we use two sample invoices describing different formats of invoice data and ask each of our SMEs to define the mappings between them and the ontologies. We also compare the results obtained with the outcome of a previous i2Ont training in order to assess the learning process of SMEs. Then we import and export 10,000 invoices compliant with the first sample into the format specified by the second sample in order to measure the second sub-dimension.

Table 2 shows the differences between the features of the i2Ont prototypes used in the previous training event and the current one. The table gives us a retrospective on the evolution of i2Ont, showing a large functionality increase in the number and types of functionalities present in the system. Such functional differences have a clear influence in the results obtained, as we will see next.

Features	eInvoicing prototype	
	Training 1	Training 2
Platform		
Type	Standalone application	NeOn Toolkit 2.X
User Interface and navigation aids		
Navigation through class relationships	Yes	Yes
Navigation through individuals relationships	No	Yes
Taxonomy navigation	No	Yes
Summarization navigation	No	Yes
Show relations through selecting invoice mapped fields	No	Yes
Search concepts	No	Yes
Highlighted mapped invoice fields	No	Yes
Highlighted compulsory relations	Yes	Yes
Managing the control of data types	No	Yes
Interaction to mapping	Selection	Drag&Drop / By suggestions
Suggestions	No	Yes
Help	No	Yes
Warnings about incompletes mappings	Yes	Yes
Available actions		
Load/Save/Reset configuration	Yes/Yes/No	Yes/Yes/Yes

Import/Export invoices	Yes(only one)/Yes(only one)	Yes(multiple invoices at once)/Yes (multiple invoices at once)
Delete generated invoices	No	Yes
Delete mapped relations	Yes	Yes
Configuration files		
Type	Properties	XML (More rich)
Ontologies		
Used	Preconfigured	Ontology from NTK project

Table 2: Comparison between i2Ont versions used in the first and second trainings

Coverage of SME-defined mappings between invoice data and the invoicing ontologies

Mappings quality

As Figure 15 shows, the average amount of erroneous mappings made by SMEs in the present user study slightly exceeds 3% for the first sample invoice while in the case of the second sample invoice this measure is less than 2.5%. These are considerably good figures, especially if we compare them with the values obtained in the previous training event, where the amount of errors is around 20% and 12% of the attempted mappings, respectively for each sample invoice.

In light of these results, we feel it is safe to say that i2Ont appears to present a monotonic property with respect to the amount of erroneous mappings and the number of training sessions received by SMEs i.e. the number of errors tends to decrease as the training increases. This property makes us conclude that, while the amount of supervision currently required by SMEs is very small (around 3%), by receiving a limited amount of additional training, SMEs would be able to do the mapping work completely on their own, without intervention of software or knowledge engineers.

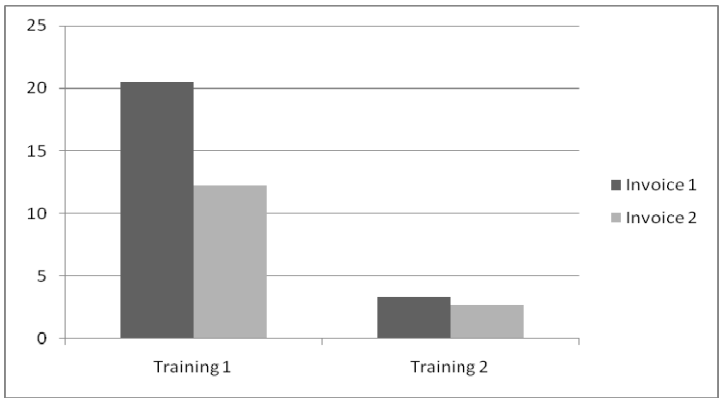

Figure 15: Percentage of erroneous mappings per invoice type and training event

In the figure, we can also observe how, in each training event, SMEs seem to become more familiar with the system as they work with it. As a consequence, SMEs commit a bigger number of mapping errors while operating with the first sample invoice, whereas their results improve for the second. This can be perceived especially in the first training event, where the amount of errors decreases by almost 50% from the first to the second invoice.

Learning curve of SMEs and degree of assistance required

Figure 16 and Figure 17 show how SMEs improve their mapping performance as they use i2Ont. Each figure shows the comparison between the average performance of SMEs while mapping invoice 1 against the values obtained with invoice 2 in the context of a particular training event. The comparison is established in terms of correct mappings versus those mappings for which SMEs required some kind of assistance in intervals of five minutes.

Figure 16 shows how the initial amount of help required by SMEs during the first training event reached its maximum at minute 10, with 70% of all mappings performed at that time. From then on, and until the end of the exercise at minute 90, the assistance required by SMEs progressively declines until it stabilizes at a value around 12% for invoice 1. In contrast to this, the proportion of correct mappings evolves logarithmically as the experiment advances. As SMEs use i2Ont and receive help from the facilitators of the exercise they actually seem to learn and improve their skills.

This is even more obvious if we look at the curves corresponding to invoice 2, mapped by SMEs immediately after invoice 1. In this case, and even though the curve corresponding to the evolution of correct mappings against time partially overlaps the analogous curve for invoice1, we perceive a clear reduction in the amount of help required by SMEs, especially at the beginning of the exercise. Not only do SMEs learn and improve their skills while using the tool, but they also remember such learning between different iterations on the mapping task.

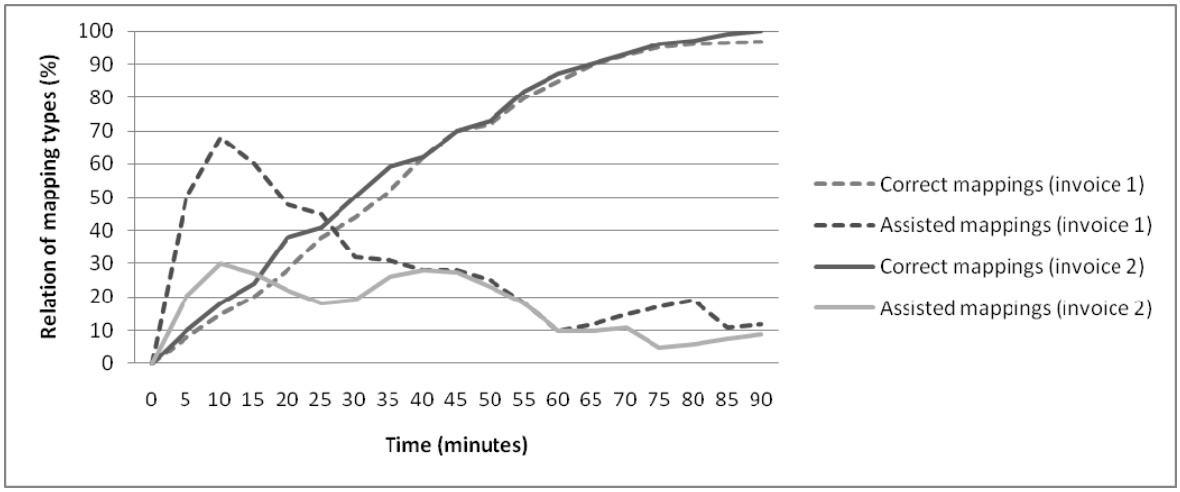

Figure 16: Comparison between correct and assisted mappings in training 1 for invoice types 1 and 2

The tendency remains and is even more acute in the second training event, as Figure 17 shows. The amount of help required either with the first or the second sample invoice never exceeds 20% during the exercise. Furthermore, it tends to decrease after minute 60. It is worth highlighting how the difference between the help required with the first and second invoices is much smaller than in the first training event. Since SMEs are better acquainted with the tool, the space for improvement and the number of issues where help may be required are smaller.

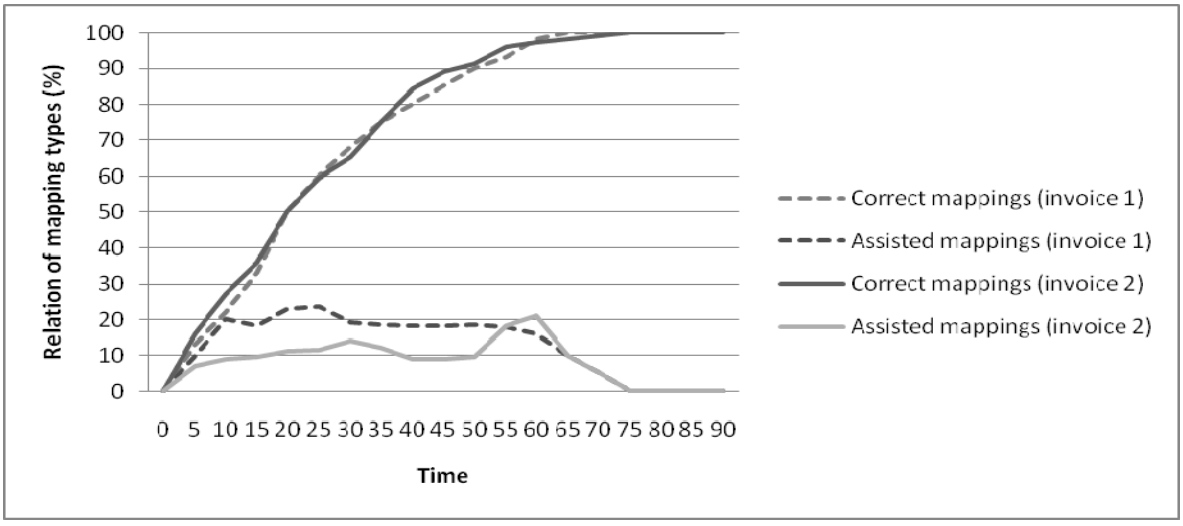

Figure 17: Comparison between correct and assisted mappings in training 2 for invoice types 1 and 2

Just like the first training event, the progressions of the amount of correct mappings tend to overlap. However, their logarithmic functions reach their asymptote, the points in time from which on all mappings are correctly defined, much earlier. While in the first training this was situated at approximately minute 85, in the second training stability is reached at minute 60. Therefore, we can conclude i) that the effect of previous trainings remains with the participant SMEs, even if they are distant in time, and ii) that i2Ont favours a

progressive learning process, allowing SMEs to have an operational command of the tool even from very early stages in their utilization.

Interoperability support for automated invoice exchange

The use of ontologies enables i2Ont to ensure the consistency of exchanged invoice data with respect to their formal model. i2Ont checks the model, including constraints on ontology properties, to detect and highlight relevant invoice data that still needs to be mapped by the SME and to avoid incorrect mappings, as well. Only once all the constraints have been satisfied does i2Ont issue a configuration file describing the correspondences between the invoice (and consequently all those invoices compliant with it) and the ontologies. All subsequent invoices received by the system are then imported into the ontology using such configuration. Therefore, provided the configuration file is correct, the import and export processes in and out of the ontologies will be correct, too.

Indeed, in the context of this evaluation all the invoices were correctly imported and exported in and out of the ontologies. Thus, we have focused on obtaining performance measures of the time required by i2Ont to perform the different operations involving invoice exchange. In order to actually import and export a test set of 10,000 invoices in and out of the invoicing ontology network through i2Ont, we have used two different configuration files resulting from the previous evaluation stage, corresponding to invoice 1 and invoice 2, respectively. This provides us with the means necessary to cover the complete invoice transformation process, supporting load and import of 10,000 invoices compliant with invoice 1 and export and save of the resulting invoice instances in a way compliant with the format of invoice 2.

Figure 18 shows the average import times for the 34 groups of 300 invoices in the test set. During the import process, ontology instances are generated from the data contained in each invoice and saved in the NeOn toolkit repository. As the figure shows, this has an accumulative effect on i2Ont's performance with an associated performance loss. As the ontology is populated with an increasing number of instances it becomes harder to index and allocate new instances. i2Ont generates a number of instances oscillating around 50 per invoice. Importing 300 invoices means that 15,000 new ontology instances will be produced, taking up almost 50 seconds to import the last invoice.

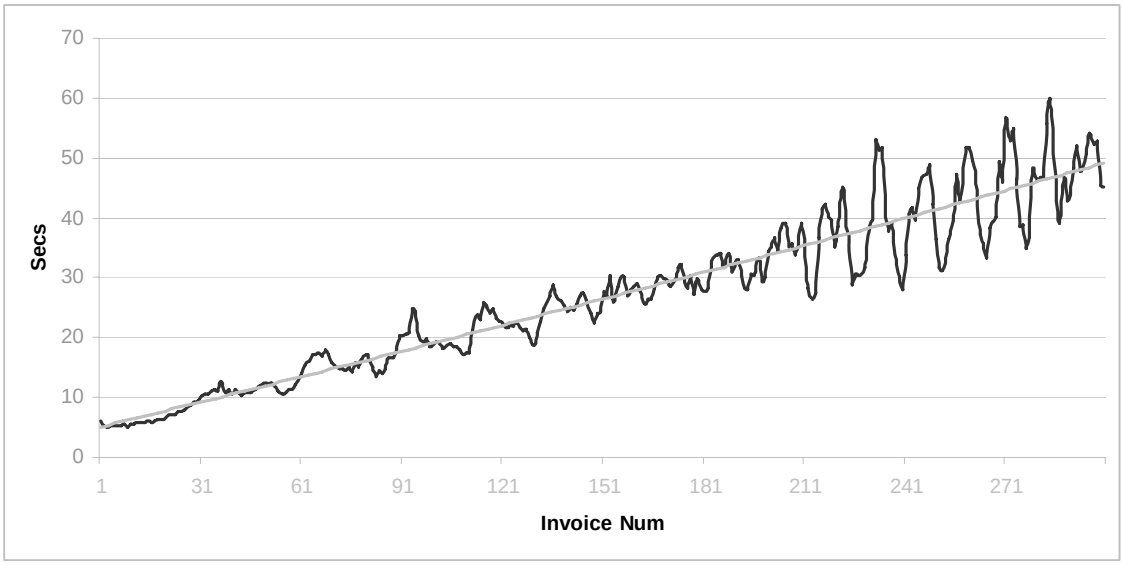

Figure 18: Invoice import into invoicing ontology network

On the other hand, the time required to export invoice data from the ontologies into a file is considerably short (around 0.2 seconds) and remains constant and independent from the amount of instances contained in the ontology, as shown in Figure 19. Altogether, this means that any eventual bottleneck to be addressed will be constrained to the invoice import phase.

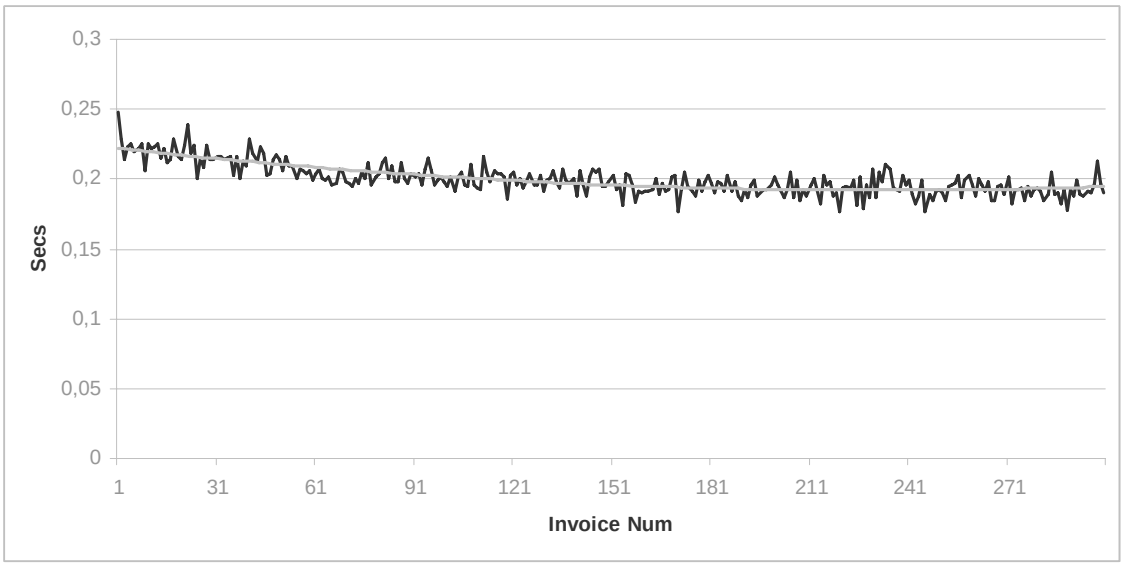

Figure 19: Export of invoice instances

4. Evaluation of the semantic nomenclature case study

4.1 Ontology assessment

The Semantic Nomenclature ontology network has been described in previous deliverables. In this section we first make a short recap of the main ontologies of the network, and later we explain the evaluation done by ontology and domain experts and the changes that we undertook during the last months as a reaction to their feedback. As shown in Figure 20, the semantic nomenclature network comprises several ontologies.

Figure 20: Semantic Nomenclature ontology network

The domain part of the ontology network consists of a subset of ontologies used to describe drugs or related concepts in accepted international terminologies. Other ontologies could be added to the network by simply mapping them to the existing ones. (i.e. Snomed CT, Mesh, NCI, etc.). At this level we also include ontologies providing a classification of pharmaceutical terms, such as the ATC[10] classification (WHO recommendation mapped to many terminologies) or the SPC model[11] (Summary of Product Characteristics), modelled as an ontology in NeOn from a physician's information document issued by the European Union.

In the application we have ontologies which represents the knowledge of the real-world resources after being re-engineered as ontologies. In the Semantic Nomenclature case study we have included as a matter of example two resources widely used in Spain with information about drugs: The Digitalis ontology,

[10] http://www.whocc.no/atcddd/

[11] http://ec.europa.eu/enterprise/pharmaceuticals/eudralex/vol-2/c/spcguidrev1-oct2005.pdf

reengineered from the governmental public database of marketed pharmaceutical products, which is the de facto Spanish standard for pharmaceutical products available in the Spanish market; and the BOTPlus ontology, modeled from the set of public information provided for this nomenclature developed by ATOS for the General Council of Pharmacists in Spain. The simple mapping of these two ontologies to other international ontologies is of a clear business and exploitation value.

The Semantic Nomenclature Application Ontology plays a central role of being the main façade of the ontology network, defining a simple and common ground for drug description and mapping different ontologies at conceptual level. Moreover, the ontology network is enriched with more resources such as the SPC, RxNorm or DrugOnto ontologies.

The analysis of the semantic nomenclature ontology network offered a valuable feedback to the case study, suggesting improvements that were carried out during the last months of the project. A summary of the main findings is the following:

1. **Incoherence in some equivalent classes**: For instance the Antineoplastic_Product from the ATC ontology had a mutually disjoint subclasses, but two of them have equivalentClass axioms that are identical to their superclass (Antineoplastic_Product). Another example of detected incoherence was related to some classes that contained axioms to restrictions with integer values filling the datatype property pathology value, but the values did not specify the integer datatype. This was solved by adding the datatype specification.
2. **Missing transitivity in some object properties.** For instance the Digitalis ontology included the hasPart pattern (from the ontology design patterns), but with no transitivity to express the parthood between components and ingredients of a drug.
3. **Missing range and domain in some object properties.** While a reasoner would simply put *owl:Thing* by default, certain editors do not provide some services by default in absence of a domain or range. In order to make up for this eventuality, we have put *owl:Thing* where domain or range was missing. However, some properties intuitively have a name that would suggest a more specific domain or range, like 'tax': in those cases, a more specific characterization has been pursued.
4. **Annotations** were missing for some ontology entities. We have added *rdfs:comment* annotations describing them.
5. **Some inverse properties were missing.** Some object properties did not explicitly state the inverse properties, such as hasIngredient and isIngredientOf in the BOTPlus ontology.
6. **Usage of wrong patterns:** In some cases the “intersection” pattern was used wrongly instead of the “union” pattern.

Some other improvements have been made to the semantic nomenclature ontologies. The ATC ontology has been streamlined. This ontology was derived from a classification scheme, and was correctly built as a

combinatorial representation of that scheme into OWL, which allows medical products to be classified by using an OWL reasoner. However, the result was a mixed ontology that talked about products and codes, and these codes are used as actual domain objects, not just data values for reference purposes. A better design represents a “classified classes”, with their codes put as data values for reference purposes.

4.2 User experience

As introduced in section 2, we classify the information drawn from the user study into a number of main categories in order to evaluate the Semantic Nomenclature from the perspective and experience of the different groups of experts during system interaction. Such categories are: user profile, usability, effectiveness, efficiency, and qualitative assessment. Next we describe our findings for each of them.

User profile

As in the case of the invoice management we were particularly focused on having two different groups of user profiles: users familiarised with the ontologies and ontology engineering tools, and domain experts with experience of dealing with drug terminologies and problems derived from managing them.

In the first evaluation session none of the users had any experience in ontology engineering, although they reckoned to have a good knowledge about the domain. In the second session, there was a more heterogeneous audience, where a third of the attendees had a good knowledge about ontology engineering on the eHealth domain, being more than the 70% eHealth specialists (doctors, hospital IT staff) plus some attendees from academia.

Usability

Usability of the NeOn Toolkit: As expected, the first group of domain experts with no training on ontology engineering tools found the functionalities of the NeOn Toollkit interesting, although they stated that the engineering part was far from their daily work. However, they did not find the tooling particularly complicated and seemed to understand and follow the training session with no specific problems. The heterogeneity of the second group made the results on usability more difficult to interpret. The ontology engineers found the Eclipse take on the NeOn Toolkit, and the extensibility provided by the plugins mechanism compelling. They especially liked the methodological approach to ontology engineering, the availability of so many plugins and the collaborative environment. A couple of ontology engineers mentioned that they missed the SVN metaphor for ontology versioning and collaborative design. On the other hand, some of the domain experts were a bit lost when using the toolkit. They reckoned that the training session before the evaluation was perhaps too detailed for them, and that they did not follow the explanations as much as their more experienced colleagues. At a functional level they found the functionality offered by some of the plugins as relevant to the domain, especially the modularization and the automatic alignment of ontologies.

Usability of the Semantic Nomenclature web application: The group of ontologists found the application interesting, but more from the development point of view rather than the actual functionality. They inquired

about the way NeOn offers services for creating web applications, and the kind of methodological and tooling support provided by NeOn. The application seemed average to them. On the contrary, the general comment of the domain experts was that the application is a good example of finding aggregated content. Some of the attendees failed to see in the application the added value for binding different vocabularies, but reckoned that it is a good approach to retrieve information about drugs from multiple resources, while others thought that the application shed some light for future developments on semantic interoperability issue. The usability of the Web application was considered only as satisfactory, because they found it difficult to start the query process by selecting a default main ontology. Some of the users stated that the function of the icons used to retrieve related resources and related data from the Linked Data cloud was not very clear. However, in general most of the users favourably evaluated the usability of the Web application (70%).

Regarding the impressions about documentation and help provided by the system, most of the users did not even try to use them. Only two of them tried this on the NeOn Toolkit, with good results.

Effectiveness and efficiency

There were no specific comments from the users about these dimensions. In general they found the experience satisfactory. The domain experts found that the mappings between the ontologies were appropriate although the knowledge base was not completely populated. Several users stated that just having an ontological model of the Digitalis ontology is a big step forward for the Spanish domain.

One important comment was that the approach of including Snomed CT on the ontology network is still not very clear, because the OWL version is still under a major revamping and needs better semantics. Ontology engineers stated that mapping Snomed to their terminologies would probably become a priority for them in the coming years.

In general, all participants thought the behaviour of the semantic nomenclature web application was correct in terms of effectiveness and efficiency, although they miss a bigger knowledge base to perform scalability tests.

Qualitative assessment

In the questionnaire the users evaluated the Semantic Nomenclature as highly relevant to the domain. In particular, most of the users thought that the approach of establishing mappings between international terminologies and medical ontologies is the way to proceed in this domain.

The average rating of several plugins used either in the training or evaluation sessions is the following:

Plugin	Relevance
Alignment	High
Watson	Moderate
Label Translator	High
R2O ODEMAPSTER	High
Modularisation	High
Evolva	-
Rating	Low
ODP	Moderate
RaDON	Moderate
Cicero	High
GATE services	-
Search Point	-
Relationship Visualizer	Moderate
OntoConto	-
OWLDoc	Low
Oyster	Low
Gontt	Moderate

Table 3: User evaluation of the relevance of some NeOn Toolkit plugins for their domain

4.3 Performance

As stated in section 2.3 in the case of the semantic nomenclature the performance evaluation is not a key aspect, because it is not the intention of the demonstrator to be deployed as such in a client installation, but to be a NeOn showcase for the medical sector and to be the vehicle to get future exploitation results (see section 5.2). Nevertheless we have done a performance evaluation around the following dimensions:

Usage of medical ontologies within the NeOn Toolkit

Medical ontologies tend to have a very large A-Box, which poses several problems such as loading in ontology editors and response time when dealing with them in applications. In the case of the semantic nomenclature the Digitalis ontology has more than 100K instances, which makes it difficult to load.

The main findings during the evaluation in this respect were that the default settings of the NeOn Toolkit where not valid to load the Digitalis or Snomed-CT ontologies. After several trials, users were able to change the settings in the eclipse.ini file to a value that allowed them to load these ontologies:

```
-clean
-showlocation
-vmargs
-DentityExpansionLimit=6400000
-Xms500m
-Xmx2g
-XX:MaxPermSize=250m
```

They found this to be quite a complex issue and suggested that it should be documented or even used by default in the NeOn Toolkit release.

Regarding the usefulness of the ontologies, a common remark in both sessions was the importance of having an ontological model for the Digitalis ontology as a result of the project. The Digitalis ontology models the governmental resource about the medicines approved in Spain, and it is publicly available as a Microsoft Access database. However, most of them declared that this situation could be highly improved by adopting an ontological model for Digitalis, and they encouraged us to pursue this issue with the Ministry of Health.

A negative comment was that there is a lack of complex axioms in some of the ontologies developed within the project, modelling aspects such as interactions between active ingredients. This was not the main goal of the case study, though, and could be further improved in future extensions.

Establishing alignments between ontologies representing drug descriptions

Users highlighted this aspect as the most important feature of NeOn for the domain. They asked about the types of mappings used in the semantic nomenclature, namely the owl:equivalentTo between classes, the owl:sameAs between instances, and the rdf:type between classes and instances. Ontology experts found it reasonable.

During the users' study participants were asked to perform an experiment using the alignment server to create mappings between a subset of our ontologies. We were asking for performing alignments at the T-Box level between the Digitalis and the Botplus ontologies and a second experiment aligning Digitalis and XXXX. In the case of the alignment between Digitalis and Botplus we used the StringDistAlignment method provided by the Alignment server.

The findings were very positive with regard to the accuracy of the mappings between Digitalis and Botplus. This was expected because both ontologies represent similar concepts with similar names. The users were asked to save the alignments in owl format for further evaluation. As Figure 21 shows, most of the alignments were correct and showed a 100% calculated accuracy.

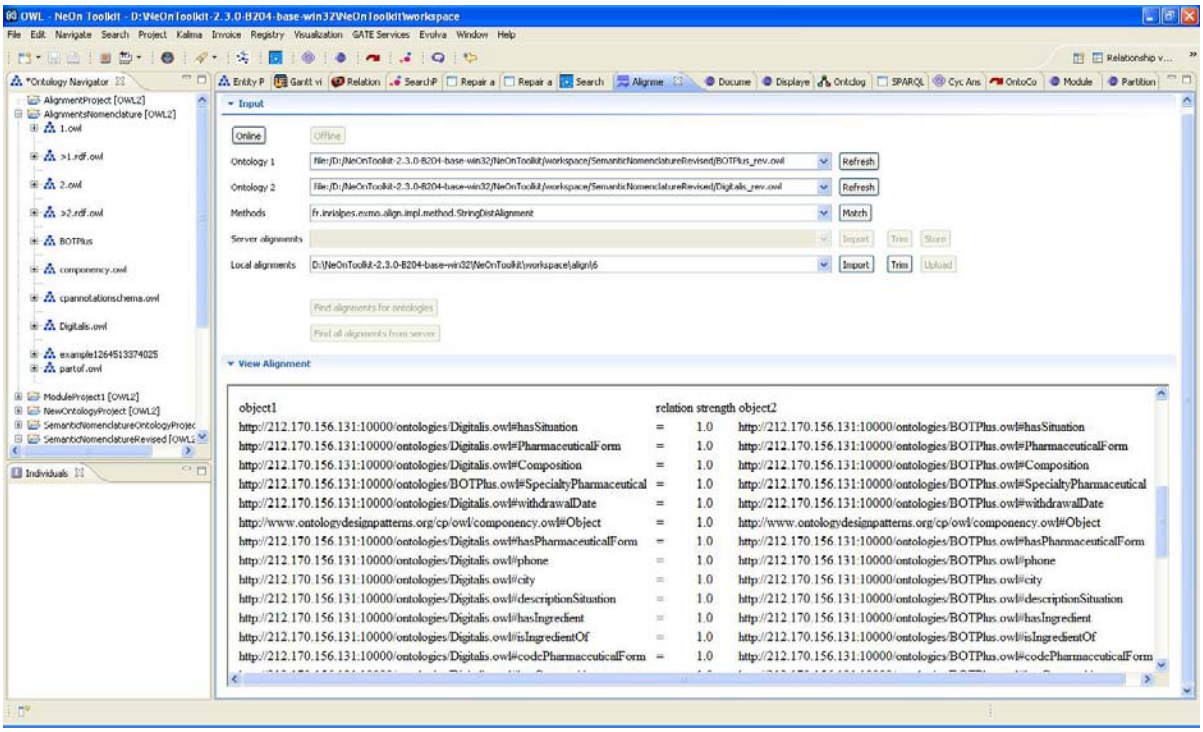

Figure 21: Alignment experiment between Botplus and Digitalis ontologies

However, this was not the case when mapping other ontologies of the network, such as RxNorm and UMLS. Some of the participants in the evaluation tried other alignment methods with no real success. After trial and error, users found some useful mappings using the NameAndProperty method as shown in Figure 22. In this case the general comment was that automatic alignment is helpful, but it is probably more suited to large T-Box.

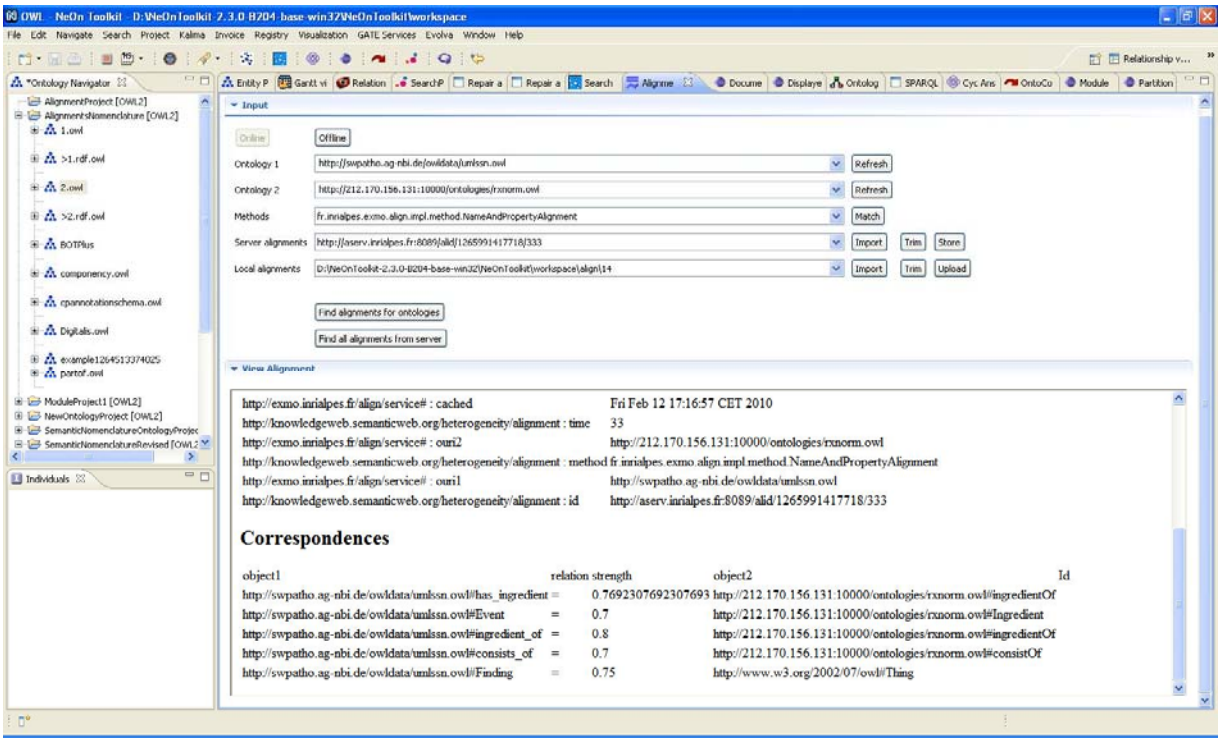

Figure 22: Alignment experiment between RxNorm and UMLS ontologies

Usage of the Semantic Nomenclature Web application

Users were faced with the Semantic Nomenclature Web application and were asked to find medicines related with a certain active principle. They based their search on the Digitalis ontology they were more familiar with, and selected the hasActiveIngredient of the PharmaceticalProduct concept of Digitalis. The search gave the expected result. In Figure 23 a similar search showing the search criteria, results and instance properties in different widgets is shown. As they also marked Botplus and the ATC as related ontologies, by clicking on the icons on the results widget related instances can be shown.

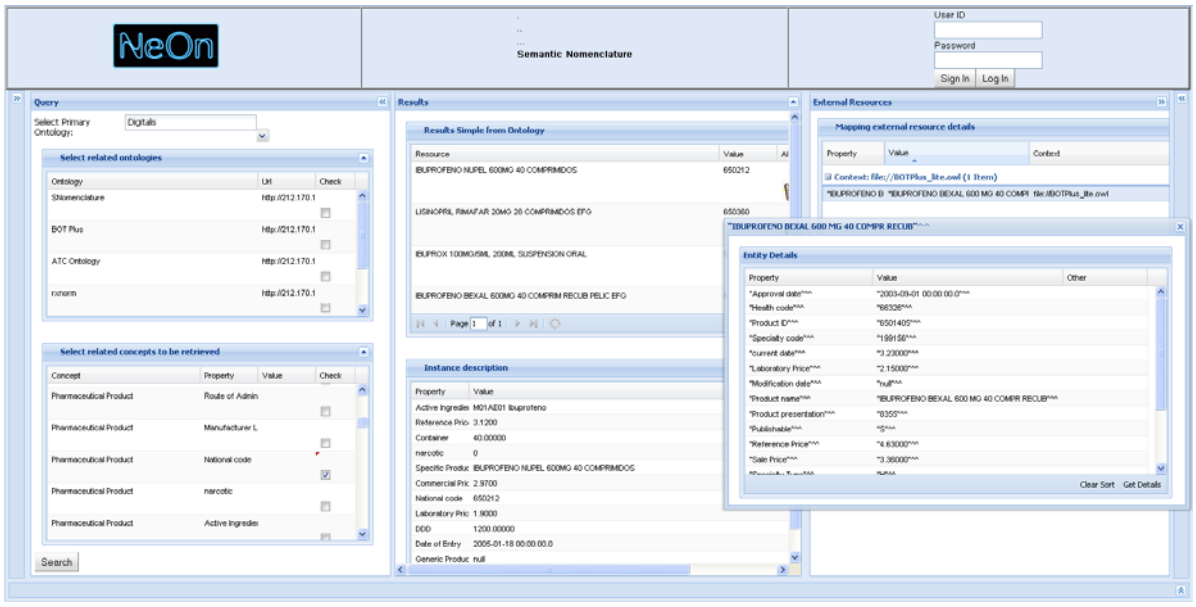

Figure 23: Search on the Semantic Nomenclature Web application

Users found the application useful to find associated information from the ontology network without having knowledge of SPARQL. At the time of the evaluation only a subset of the instances of the available ontologies were uploaded to the server, so the participants asked for a second round in the future.

The general impression of the participants of the evaluation was positive. They offered interesting feedback on the way of presenting the information. In particular they asked for a more compact user interface and a better way of inserting the selection criteria. This feedback is being taken into account for the final release of the web application.

5. Exploitation roadmap

5.1 Exploitation roadmap for the outcomes of the invoicing case study

i2Ont's exploitation roadmap starts from the integration of i2Ont technology with the PharmaInnova platform and its subsequent exploitation by PharmaInnova and its members. For this purpose, we have liaised with PharmaInnova and developed a new version of i2Ont that takes into account the outcomes of the evaluation along the different dimensions described above. The resulting software is a web application called PharmaInvoicing, which presents functional and usability enhancements with respect to i2Ont, which improve import and export performance and user interaction, respectively.

PharmaInvoicing covers the whole electronic invoicing lifecycle, introduced in deliverable D8.1.1 and shown in Figure 24. It also includes a back-office providing i2Ont's functionalities for SMEs to configure the correspondences (mappings) between their invoices, using a single sample invoice, and PharmaInnova's model.

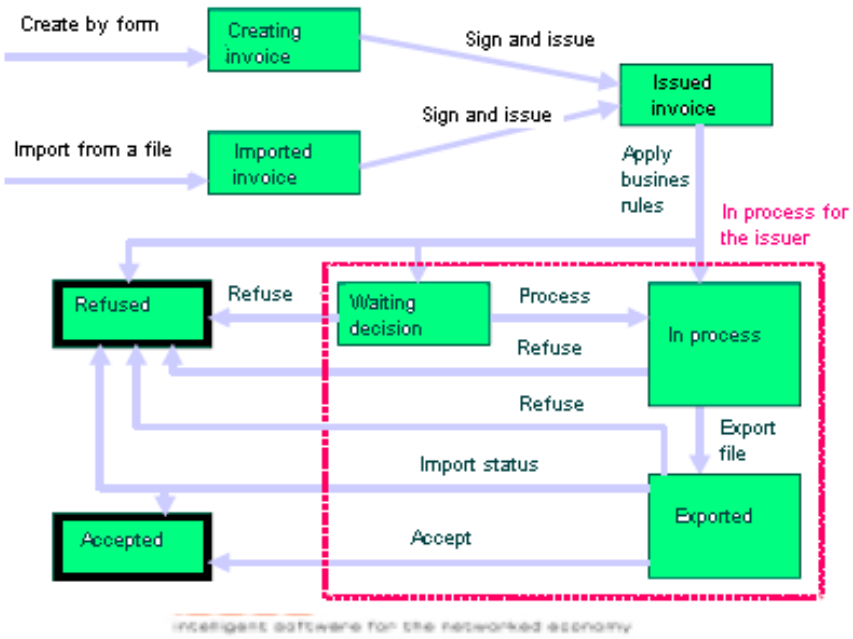

Figure 24: Electronic invoicing lifecycle

Figure 25 shows a screenshot of PharmaInvoicing's invoice configuration back-office. On the right-hand side, the graph displayed is a graphic, interactive representation of our invoicing ontology network, which has been customized for the case of PharmaInnova with a look and feel more specific to the pharmaceutical domain. Usability improvements include new icons for the branches of the ontologies representing the different sub-domains e.g. geographical locations, currencies, etc. and invoice sections e.g. header, summary, and body.

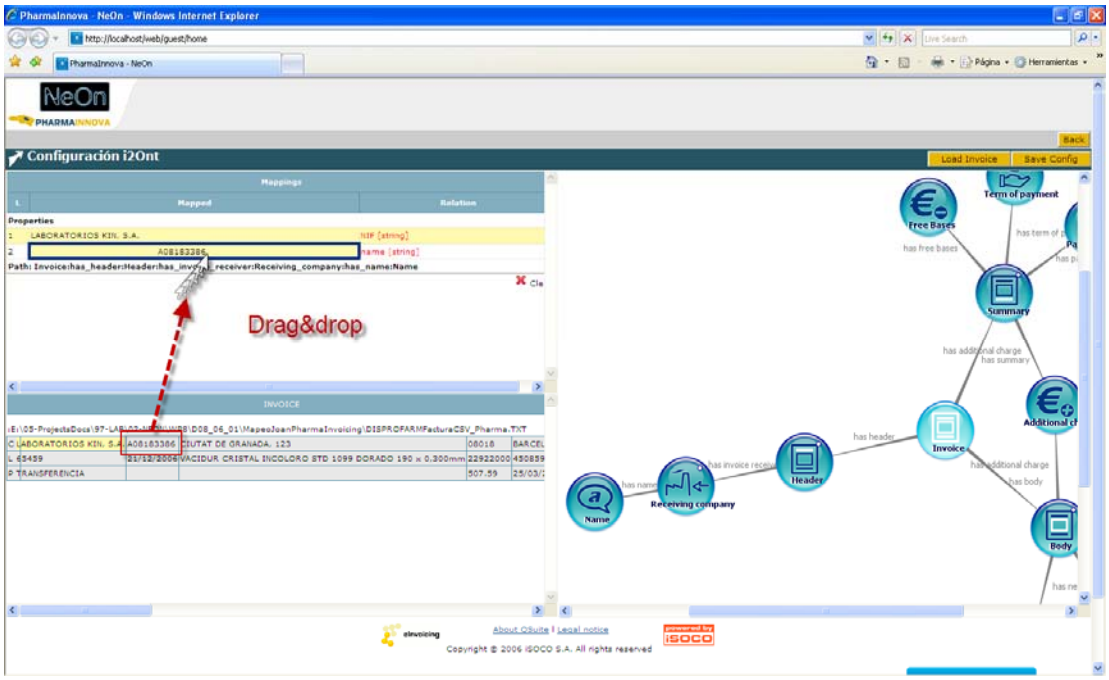

Figure 25: PharmaInvoicing configuration back-office

Once the mappings are defined, the use of PharmaInvoicing is completely transparent from the underlying networked ontologies and NeOn technology. Invoices can be imported, exported, accepted, rejected, and electronically signed, just like they are without NeOn, the only difference being the savings in terms of saved money, time, and effort of IT experts in implementing ad-hoc software for translating invoice data from one format and model to another. Figure 26 illustrates this for the case of invoice import.

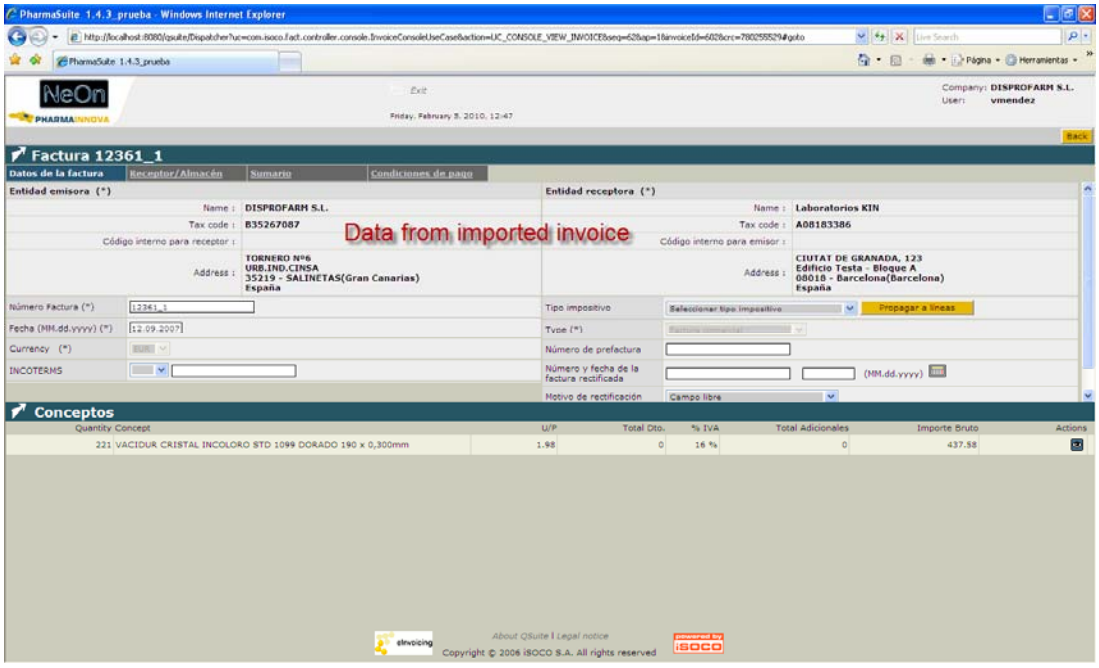

Figure 26: Managing electronic invoices with PharmaInvoicing

As shown in Figure 27, PharmaInvoicing is in the centre of PharmaInnova's innovation roadmap, establishing a two-staged strategy towards exploitation of the tool. In the first stage, PharmaInvoicing will be deployed and used internally by the partners and stakeholders in their commercial transactions. The knowledge obtained during this stage will help with validating the tool, supporting its refinement and eventual release as a product. The second stage will benefit from this and will observe the exploitation of the tool in a broader context, aiming for pharmaceutical laboratories outside of PharmaInnova.

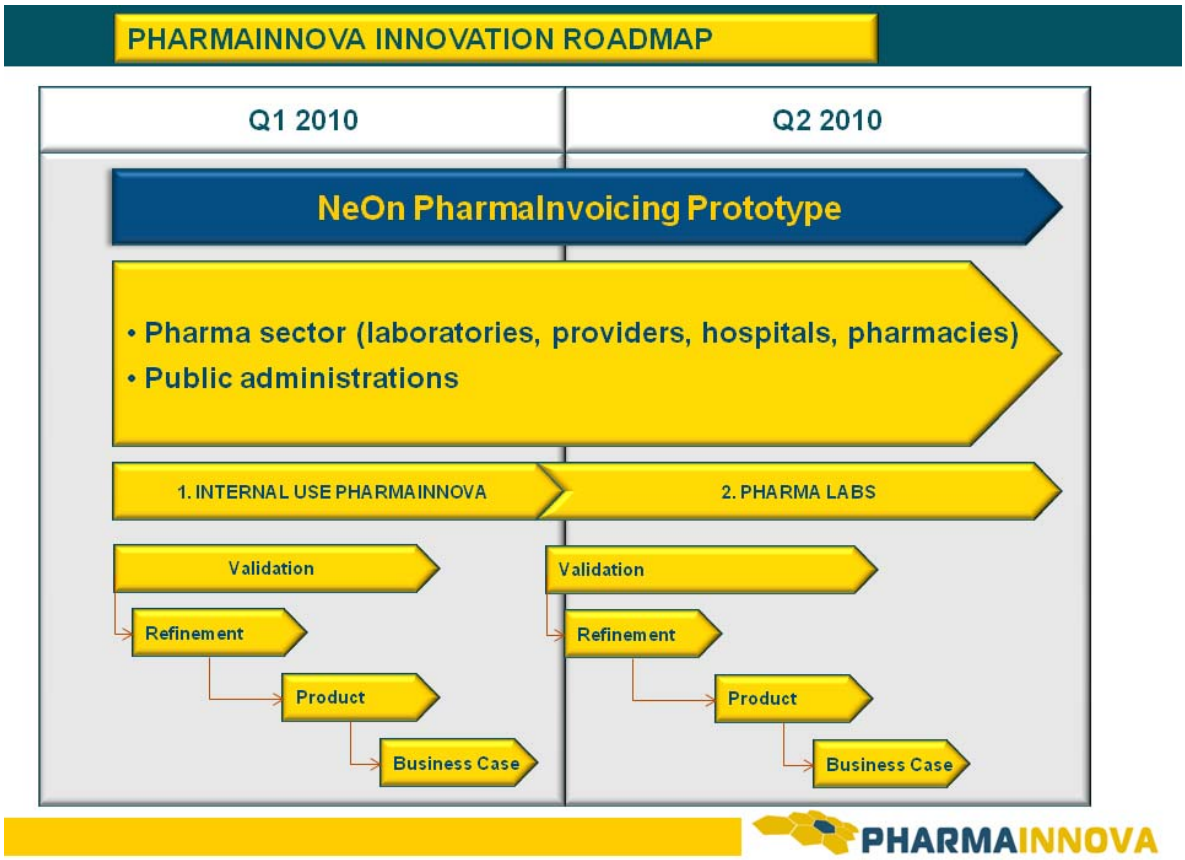

Figure 27: PharmaInnova innovation plan

In parallel to these two stages, we will pursue exploitation opportunities for electronic invoicing out of the pharmaceutical sector, especially in public administrations. PharmaInnova and its technological partner iSOCO plan to offer i2Ont's functionalities in SaaS mode (Software as a Service), which provides computer-based services to customers over the network reducing initial costs and avoiding maintenance tasks on the customer's side. This will allow the members of PharmaInnova to freely use the tool, while charging a fee to external users like e.g. laboratory providers will be possible.

5.2 Exploitation roadmap for the outcomes of the semantic nomenclature case study

The exploitation roadmap of the semantic nomenclature case study is quite different to the one of the invoicing case study. We are going to follow different exploitation lines:

1. Enhance BOTplus with mappings to other terminologies: BOTplus is a product developed by ATOS for the General Spanish Council of Pharmacists (GSCoP)[12]. In the professional sphere, the GSCoP conducts various activities aimed at the association (over 50,000 association members, mostly pharmacists), such as the Health Information Data Base (BOTplus), scientific publications, technical, professional and legal advice, continuous training activities, and the application of communication technologies for its own purposes, as demonstrated by Portalfarma. In BOTplus, pharmacy professionals have access to harmonised, updated information on medicines and patients. It provides information on diseases, symptoms, epidemiology, treatments, the detection of problems related to medicines, etc. All entries are harmonised, so that it will also be possible to save and retrieve data in any pharmacy in Spain on any patient who so requests, thereby guaranteeing a common data structure. However this data structure is not based on international standards (except the ATC codes from the World Health Organization), which poses a problem in terms of interoperability. The BOTplus medicine database was the main source from where, within the case study, we extracted a public model and data to populate the Botplus ontology. It is in the exploitation plans of ATOS bringing to our clients the possibility of using the ontological model of Botplus to enhance the current application by mapping Botplus to other national and international terminologies. In doing so, the GSCoP will benefit from a better information gathering mechanism to populate their database or to show related information to their associates. The GSCoP is aware of the developments done within the case study.
2. Exploitation of the NeOn technology: Apart from the obvious application of the semantic nomenclature to enhance BOTPlus, we are also initiating contact with several potential clients to foster the usage of NeOn technology in different domains. In the eHealth domain, we demonstrated the tool to representatives of the Ministry of Health (owners of the publicly available Digitalis database, from which we modelled the Digitalis ontology) in order to show them the benefits of exposing their data in a semantic way. Contact will be made again in the near future. We have also used NeOn technology internally in ATOS to demonstrate both internally and to our clients the potential of the technology. We developed a prototype, the ATOS semantic portfolio, which makes use of ontologies developed using the NeOn Toolkit and the NeOn methodology. This prototype was showed in the last Innovautas event[13] and raised positive comments from various client organisations. We have also initiated contact with different vertical market representatives within ATOS to make this technology available in their discussions with clients.
3. Semantic interoperability roadmap. All around the world the concept of semantic interoperability in eHealth is being given a lot of attention. In Europe, the SemanticHEALTH project[14] wrote a roadmap explaining the timing, research challenges and the necessary technologies to achieve it. Among the

[12] http://www.portalfarma.com/home.nsf/cmPortalIngles?OpenFrameset

[13] http://avatar.atosorigin.es/innovacion09/innovautas/inn09/inicio.html

[14] http://www.semantichealth.org

research challenges there is a specific section regarding technologies, and in particular what the limits are of the OWL expressiveness and the lack of tools for tasks such as collaborative ontology design, ontology modularization and ontology mapping, among others. In Spain there is also a debate about semantic interoperability. The Ministry of Health gathered an expert committee composed by representatives from different organizations (hospitals, public organizations and academia) to elaborate a specific roadmap for achieving semantic interoperability in Spain. We have been in contact several times with some of the members of this committee to explain the NeOn perspective and tools, and they are aware of the potential of NeOn to overcome some of the technical challenges already stated by SemanticHEALTH and acknowledged by the Spanish eHealth community. To this end, we presented a research proposal last year to a Spanish research Avanza programme including the usage of NeOn, and we continue to offer training courses (the last one in Barcelona in February 2010) to foster the usage of NeOn for ontology development within the medical community in Spain.

4. New research projects: We are involved in several research projects using NeOn technology including: the Spanish Buscamedia project[15] lead by ATOS, where we are developing a set of ontologies to model and annotate media assets; and the Web n+1 project, lead by iSOCO, where the NeOn methodology and the NeOn toolkit is being used to develop ontologies to annotate and manage web portals and media content. We are also hopefully using NeOn technology in the recently started FP7 Call 4 TaToo project. This gives an idea of the serious approach we are giving to reuse and enhance the NeOn results in upcoming research projects.

[15] http://mtg.upf.edu/project/buscamedia

6. Conclusions

In this document, we have presented and executed a thorough evaluation method, which has served to evaluate the outcomes of NeOn's pharmaceutical case studies from a number of different but complementary perspectives, including ontology assessment, user experience, and performance. The evaluation has helped us identify possible improvements for the ontologies and software of the case studies, favouring the release of refined and definitive versions, with a clearer exploitation landscape. We have also included short and mid term exploitation roadmaps for the results of the two case studies, which are well-defined, especially in the case of electronic invoicing where PharmaInnova foresees (and pursues) deployment of i2Ont functionalities in 2010.

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Appendix A – Evaluation material used for the invoicing case study

This section contains some samples files used in the PharmaInnova case study. It also includes references to the evaluation materials used in the 2nd Training at KIN Laboratories.

Sample invoices

These files below are two sample invoices about the provider domain:

File: InvoiceProvider2.ilo

"1";"43021";"Laboratorios Almirall, S.A.";"ESA58869389";"Rda.Gral.Mitre, 151";"08022";"Barcelona";"Barcelona";"ESP";"207352";17/04/2009;"Prov. 1";"ESA11111111";"C/Lepanto 123";"08025";"Barcelona";"Barcelona";"ESP";"EUR";"F";""
"2";"10114";"45101983";"30";"4322";"07719";14/04/2009;"46322702";"E.EBASTEL FORTE 20 MG.20 COMP";77900;0;0;10;779;16
"2";"10173";"45102755";"10";"4322";"07720";14/04/2009;"46045501";"E.PARAPRES 4MG. 14C. IMA";15840;0;0;15;237,6;16
"2";"10228";"45103636";"10";"4322";"07721";15/04/2009;"46045201";"E.PARAPRES 8MG. 28C. IMA";60250;0;0;20;1205;16
"2";"10233";"45103681";"10";"4322";"07724";17/04/2009;"46084802";"E.CICLOFALINA 800MG.60C.";50800;0;0;25;1270;16
"2";"10234";"45103713";"10";"4322";"07722";15/04/2009;"46321103";"E.ASTUDAL 10Mg. 30C.";62040;0;0;20;1240,8;16
"2";"10236";"45103743";"10";"4322";"07723";15/04/2009;"46109501";"E.KESTINE 30MG. 20C. GRECIA";35900;0;0;15;538,5;16
"2";"10243";"45103775";"10";"4322";"07725";17/04/2009;"23240005";"E.VITAMINA D3 10ML. SOL.OL.KER";283500;0;0;10;2835;16
"3";"4322";"Transferencia";"15 días F.F.";9402,84;01/05/2009;8105,90;1,25;180,30;8105,90;8105,90;1296,94;9402,84

File: InvoiceProvider1.ilo

"1"#"43021"#"Laboratorios Almirall, S.A."#"ESA58869389"#"Rda.Gral.Mitre, 151"#"08022"#"Barcelona"#"Barcelona"#"ESP"#"207352"#17042009#"Prov. 1"#"ESA11111111"#"C/Lepanto 123"#"08025"#"Barcelona"#"Barcelona"#"ESP"#"EUR"#"F"#""
"2"#"10114"#"45101983"#"30"#"4322"#"07719"#17042009#"46322702"#"E.EBASTEL FORTE 20 MG.20 COMP"#77900#0#0#10#779#16
"2"#"10173"#"45102755"#"10"#"4322"#"07720"#17042009#"46045501"#"E.PARAPRES 4MG. 14C. IMA"#15840#0#0#15#237,6#16
"3"#"4322"#"REPOSICION 90 DIAS#"15 días F.F."#9402,84#01052009#8105,90#1,25#180,30#8105,90#8105,90#1296,94#9402,84

More configuration files at: http://www.neon-project.org/ACollab/drafting/revisions.php?id=1305

Sample configuration file

This is a sample configuration about the Disprofarm invoice model:

DISPROFARMFormat.cfg

```
<?xml version="1.0" encoding="UTF-8"?>
<mapping>
```

```
<config>
        <project>NewOntologyProject</project>
        <ontology>http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl</ontology>
        <invoiceConcept id="Invoice"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <headerRelation id="has_header"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <bodyRelation id="has_body"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <summaryRelation id="has_summary"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <headerConcept id="Header"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <bodyConcept id="Body"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <summaryConcept id="Summary"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl"/>
        <type id="csv" dateFormat="ddMMyyyy" decimalSeparator=",">
                <csvConfig>
                        <separator>#</separator>
                </csvConfig>
        </type>
</config>
<invoice>
        <header>
                <concept id="Header"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                        <property id="has_client"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                <concept id="Client"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                        <property id="has_address"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                <concept id="Address"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                        <property id="has_street"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                                <concept id="Street"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                                        <property id="postal_code"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                                                <localization>
                                                                                        <csv>

        <col>5</col>

        <row>0</row>
                                                                                        </csv>
                                                                                </localization>
                                                                        </property>
                                                                </concept>
                                                        </property>
                                                </concept>
                                        </property>
                                </concept>
                        </property>
                </concept>
                <concept id="Header"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                        <property id="Type_of_document"
```

```
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                        <localization>
                                                <csv>
                                                        <col>19</col>
                                                        <row>0</row>
                                                </csv>
                                        </localization>
                                </property>
                        </concept>
 [……
  ……..]
                </header>
                <body>
                        <concept id="Body"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                <property id="delivery_date"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                        <localization>
                                                <csv>
                                                        <col>6</col>
                                                        <row>1</row>
                                                </csv>
                                        </localization>
                                </property>
                        </concept>
[  ……
  ……..]
                </body>
                <summary>
[  ……
  ……..]
                        <concept id="Summary"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                <property id="has_term_of_payment"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                        <concept id="Term_of_payment"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                <property id="has_expiry"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                        <concept id="Expiry"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                                <property id="Date"
ontology="http://www.isoco.com/ontologies/neon/PharmaInnovaInvoiceOntology.owl">
                                                                        <localization>
                                                                                <csv>
                                                                                        <col>5</col>
                                                                                        <row>3</row>
                                                                                </csv>
                                                                        </localization>
                                                                </property>
                                                        </concept>
                                                </property>
                                        </concept>
                                </property>
                        </concept>
[  ……
  ……..]
                </summary>
        </invoice>
</mapping>
```

More configuration files at: http://www.neon-project.org/ACollab/drafting/revisions.php?id=1305

Reference to the questionnaire used in the 2nd Training

Setting

A-1. The ontology platform used during the experiment is:

Protege	*TopBraid*	*NeOn toolkit*	*Other*

A-2. Please, list briefly other tools used during the experiment.

A-3 How would you rate your previous experience with the tools used in the test?

Beginner	*Moderate*	*Expert*	*NA/DK*

A-4. If any, please list what additional tools you would have found useful.

Tasks observation (User Profile)

B-1. How would you rate your previous experience in ontology engineering?

Beginner	*Moderate*	*Expert*	*NA/DK*

B-2. Did you already have experience in electronic invoicing?

Beginner	*Moderate*	*Expert*	*NA/DK*

Please indicate how you perceived the amount of time needed to execute each of the tasks of the experiment:

Task1:

Low	*Average*	*High*	*NA/DK*[16]

Task2:

Low	*Average*	*High*	*NA/DK*

B-2. Your understanding of the tasks comprised in the experiment was:

Low	*Average*	*High*	*NA/DK*

B-3. Please, briefly describe your approach to Task 1 of the experiment.

B-4. Please, briefly describe your approach to Task 2 of the experiment.

B-5. The difficulties you needed to overcome due to the i2Ont plugin used during the experiment in order to complete each task were:

	Low	*Average*	*High*	*NA/DK*
Task 1				
Task 2				

B-6. How did you find the support provided by the facilitator?

Inadequate	*Adequate*	*Excellent*	*NA/DK*

Usability

Help and documentation quality

C-1a. Please indicate how useful you found the documentation in the i2Ont and tools used.

[16] NA/DK=Not Appplicable/Don't Know

Not very	*Reasonably*	*Very*	*NA/DK*

C-1b. Did you find the tooltips provided by the tools were sufficient?

Not very	*Reasonably*	*Very*	*NA/DK*

Interface design/accesibility quality

C-2a. Please indicate how well designed you felt the system interface was

Not very	*Reasonably*	*Very*	*NA/DK*

C-2b. Did you find the graphic elements, e.g. icons, of your tool clear and legible?

Not very	*Reasonably*	*Very*	*NA/DK*

C-2c. Do you find it necessary greater customization regarding fonts or colours in your tool?

Not very	*Reasonably*	*Very*	*NA/DK*

C-2d. Did you find support for the following languages in the available tools:

	Satisfactory	*Not present but useful*	*Not needed*
English			
Spanish			
German			
French			
Others			

C-2e. What other forms of customization do you find necessary?

C-2f. Are you satisfied with the interface design of the tools?

Not very	*Reasonably*	*Very*	*NA/DK*

C-2f. Please, briefly list any suggestion to improve accessibility

Hands –on experience

Effectiveness

D-1a. Did you find any problems loading the ontologies? If so, briefly list them.

D-1b. As a domain expert (electronic invoicing), how do you think about domain coverage provided by the invoicing ontologies according to the SMEs:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

D-1c. If not, what is missing? what is incorrect? what is superfluous?

D-1d. Please indicate how ease of bootstrapping with i2Ont and the NeOn Toolkit available tools.

Not very	*Reasonably*	*Very*	*NA/DK*

D-1e. Did you find the i2Ont used allows setting a clear and simple sequence of steps to accomplish each necessary action, e.g. make a relation between one field of the invoice and one data property of the ontology:

Not very	*Reasonably*	*Very*	*NA/DK*

D-1f. What was the major obstacle that you found during hands-on work with the system?

D-1g. Was the overall behaviour of the i2Ont and NeOn Toolkit tools:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

Efficiency

D-2a. Please, in case you consider it necessary, describe how the i2Ont should be improved in order to facilitate some specific task over invoices.

D-2b. Please write a list with approximately the five most repeated operations during your interaction with the tools available during the experiment:

Operation	*Description*

D-2c. Did your ontology editor allowed you to have all the necessary information about the different ontologies handy:

Not very	*Reasonably*	*Very*	*NA/DK*

D-2d. Was there any of the tools described in A-2 apart from the i2Ont that was essential to you during the experiment? Which one(s)?

Design Experience

D-3a. Did you find capabilities to flag ontology entities worked on, e.g. in order to allow quick location of important concepts later:

Satisfactory	*Not present but useful*	*Not needed*	*NA/DK*

D-3b. Did you find support provided by the editor to handle nested/dependent ontologies:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

D-3c. Did you find support to handle heterogeneous namespaces of the different ontologies:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

D-3d. How easy was it to perform search and/or replace in multiple places of the ontologies:

Not very	*Reasonably*	*Very*	*NA/DK*

D-3e. Did you find capabilities provided by the ontology editor to momentarily hide parts of the ontologies:

Satisfactory	*Not present but useful*	*Not needed*	*NA/DK*

NeOn Objectives

Visualization

E-1a. As an expert in the domain (electronic invoicing), do you feel that the i2Ont visualization methods contribute adequately to represent the description of the domain as contained in the ontology in a way:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

E-1b. How did you find the model visualization based on both taxonomies and relations?

Inadequate	*Adequate*	*Excellent*	*NA/DK*

E-1c. Do you think it would be useful to visualize several branches of the ontology/ies simultaneously?

Not very	*Reasonably*	*Very*	*NA/DK*

E-1d. Do you think it would be useful to graphically realize operations between several branches of the ontology/ies? For example, create a mapping between two concepts.

Not very	*Reasonably*	*Very*	*NA/DK*

Reuse

E-2a. Did you find that the support provided by the ontology editor allowed to reuse existing ontologies:

Not very	*Reasonably*	*Very*	*NA/DK*

E-2b. Was the support provided for partial ontology import, e.g. a selected branch:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

Context

E-3. How easy was it to perform contextual changes in the ontologies. For example, in the “Copyright” ontology, the transition from “Person” to “Legal-Agent” after import of the “AKT Portal” ontology:

Not very	*Reasonably*	*Very*	*NA/DK*

Mapping

E-4a. How useful do you find the i2Ont as perceived by SMEs (establishing mappings between ontology and invoice):

Not very	*Reasonably*	*Very*	*NA/DK*

E-4b. Do you find the support for establishing mappings between concepts from different ontologies:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

E-4c. How useful would you find an automatic mechanism to ensure mapping consistency in a netoworked ontologies-compliant editor:

Not very	*Reasonably*	*Very*	*NA/DK*

Versioning

E-5a. Do you find the support for creating and maintaining versions of ontological knowledge:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

E-5b. How useful would you find an automatic mechanism to propagate updates through dependencies across ontologies. For example, between the Copyright ontology and the AKT Support ontology, where concept “CreationProcess” in the first depends from concept “Temporal-thing” in the second:

Not very	*Reasonably*	*Very*	*NA/DK*

E-5c. How useful would you find to apply the CVS metaphor to the ontology editor:

Not very	*Reasonably*	*Very*	*NA/DK*

E-5d. How useful do you find to be able to visually compare different versions of the same ontology:

Not very	*Reasonably*	*Very*	*NA/DK*

Reasoning

E-6a. Do you find the reasoning capabilities of the framework used:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

E-6b. If any, please briefly list those features that you find missing.

Storage

E-7a. Do you find the different formats (RDF, OWL, Flogic...) available for ontology storage:

Inadequate	*Adequate*	*Excellent*	*NA/DK*

E-7b. If any, please briefly list those that you find missing.

Practical matters

F-1. What functionalities would you like to see in next versions of your ontology editor?

F-2. Please, add any critical comments or positive suggestions on how the system might be improved.

Any other comments or suggestions

G-1. Finally, could you add any comments, criticisms or suggestions about any aspect of the system not covered in the above questions. Thanks for your cooperation in this.

The file with the questionnaire is located at:

http://www.neon-project.org/ACollab/drafting/revisions.php?id=1304

Appendix B – Evaluation material of the semantic nomenclature

This appendix contains the reference to the questionnaire used in the two evaluation sessions of the Semantic Nomenclature case study, plus a set of links to more material related with the evaluation.

Questionnaire used

Setting

A-1. The ontology editor used during the evaluation:

NeOn Toolkit

A-2. Please, list briefly other tools used during the evaluation.

Cupboard

Semantic Nomenclature Web Application

A-3. If any, please list what additional tools you would have found useful.

Evaluation observation

B-1. How would you rate your previous experience in ontology engineering and with the tools used?

	Beginner	*Moderate*	*Expert*	*NA/DK*
Ontology Editors				
Other Nomenclatures				
NeOn Toolkit				
Semantic Nomenclature				

B-2. Did you already have experience with the ontologies, vocabularies or resources used during the evaluation?

	Yes/No	Ontology/Vocabulary/Database/Heard of…
Nomenclator Digitalis		
BOTPlus		
ATC		
Snomed-CT		
UMLS		
SPC		
RxNorm		

B-3. Please, briefly describe your general impression of the tools

NeOn Toolkit	
Semantic Nomenclature	

B-4. The difficulties you needed to overcome due to the ontology editor and tools used during the evaluation were:

	Low	*Average*	*High*	*NA/DK*
NeOn Toolkit				
Semantic Nomenclature				

B-5. How did you find the support provided by the facilitator?

Inadequate	*Adequate*	*Excellent*	*NA/DK*

Usability

Help and documentation

C-1a. Please indicate how useful you found the documentation in the tools and editors used.

	Not very	*Reasonably*	*Very*	*NA/DK*
NeOn Toolkit				
Semantic Nomenclature				

Interface design/accesibility

C-2a. Please indicate how well designed you felt the system interface was

	Not very	*Reasonably*	*Very*	*NA/DK*
NeOn Toolkit				
Semantic Nomenclature				

C-2b. Did you find the graphic elements, e.g. icons, of your editor clear and legible?

	Not very	*Reasonably*	*Very*	*NA/DK*
NeOn Toolkit				
Semantic				

Nomenclature				

C-2c. What other forms of customization do you find necessary?

C-2d. Are you satisfied with the interface design of the editor?

	Not very	*Reasonably*	*Very*	*NA/DK*
NeOn Toolkit				
Semantic Nomenclature				

C-2e: Please, briefly list any suggestion to improve accessibility

Hands–on experience

Effectiveness

D-1a. Did you find any problems using the ontologies? If so, briefly list them.

D-1b. As a domain expert do you think the ontologies used represent the domain?

Inadequate	Adequate	Excellent	NA/DK

D-1c. If not, what is missing? What is incorrect? What is superfluous?

D-1d. Please indicate how easy you found to get acquainted with the evaluation ontologies by means of the available tools.

	Not very	Reasonably	Very	NA/DK
NeOn Toolkit				
Semantic Nomenclature				

D-1e. Did you find the tools useful to get similar information from different data resources?

	Not very	Reasonably	Very	NA/DK
NeOn Toolkit				
Semantic Nomenclature				

D-1f. What was the major obstacle that you found during your work with the system?

D-1g. Was the overall behaviour of the ontology editor and tools:

Inadequate	Adequate	Excellent	NA/DK

Efficiency

D-2a. Please, in case you consider it necessary, describe how the ontology editor should be improved in order to facilitate some specific ontological task.

D-2b. Please, in case you consider it necessary, describe how the Semantic Nomenclature application should be improved in order to facilitate some desirable tasks.

Semantic Nomenclature qualitative assessment

E-1. As an expert in the domain, do you feel that the tools used contribute to representing the description of the domain?

Inadequate	Adequate	Excellent	NA/DK

E-2. How useful do you find to establish mappings between concepts of different pharma ontologies?

Not very	Reasonably	Very	NA/DK

E-3. How did you find the visualization and search results of interdependencies between different components of the ontology network?

Inadequate	Adequate	Excellent	NA/DK

E-4. Did you find that the support provided by the ontology editor allowed reusing existing ontologies?

Not very	Reasonably	Very	NA/DK

E-5. Did you find support for adding new ontologies to the Semantic Nomenclature network?

Inadequate	Adequate	Excellent	NA/DK

E-6. Did you find support for establishing mappings between concepts from different ontologies?

Inadequate	Adequate	Excellent	NA/DK

E-7. How useful would you find an automatic mechanism to ensure mapping consistency in a netoworked ontologies-compliant editor?

Not very	Reasonably	Very	NA/DK

E-8. Could you rate the NeOn plugins or technology you find more useful for your domain?

	Not very	Reasonably	Very	NA/DK
Alignment				
Watson				
Label Translator				
R2O ODEMAPSTER				
Modularisation				
Evolva				
Rating				
ODP				
RaDON				
Cicero				
GATE services				
Search Point				
Relationship Visualizer				
OntoConto				
OWLDoc				
Oyster				
Gontt				
Others				

E-9. If any, please briefly list those features that you find missing.

Practical matters

F-1. What functionalities would you like to see in next versions of your ontology editor and Semantic Nomenclature application?

F-2. Please, add any critical comments or positive suggestions on how the system might be improved.

Any other comments or suggestions

G-1. Could you suggest possible future scenarios of usage of this technology in your domain?

G-2. Finally, could you add any comments, criticisms or suggestions about any aspect of the system not covered in the above questions? Thanks for your cooperation in this.

Other material

More material related with the training and evaluation sessions can be found in the NeOn collab space at http://www.neon-project.org/ACollab/drafting/index.php?id=173