SEMANTIC FRAMES
A Way for Automating the Management of Medicinal Documents

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Abstract: Knowledge management concerns with acquiring, accessing and maintaining knowledge within an organization. Knowledge management is also important because organizations view internal knowledge as an intellectual asset from which they can draw greater productivity, create new value, and increase their competitiveness. We have investigated the management of knowledge in pharmacies. It has turned out that the volume of information coming in from a variety of information sources such as pharmaceutical companies, medicinal wholesalers, social insurance institutions and other authorities is increasing all the time. Further, the various formats such as paper, fax, email, and a wide variety of multiple electronic media formats are still complicating the information management. In order to alleviate this problem, we have introduced the notion of semantic frames, which are included in incoming XML-documents. The frames specify how to integrate the incoming document into the medicinal ontologies and taxonomies in the pharmacy system. Further, as our used ontology models the relationships of the incoming documents and the daily duties, the integration of the documents and daily duties can be automatically done. The gain of this approach is that the documents (medicinal instructions) are provided just-in-time, and tailored to their specific needs. An essential prerequisite of our approach is that the healthcare organizations that send the documents and the receiving pharmacies have to commit to the same medicinal ontologies, i.e., they have to use the same vocabulary in specifying and interpreting the semantic frames.

1 INTRODUCTION

Healthcare is a field where the fast development of drug treatment requires specialized skills and knowledge. As a result the amount of new medicinal information increases all the time.

The problems arising of increased medicinal information are discussed in many practitioner reports and public national plans, e.g., in (Hyppönen et al., 2005; Dwivedi et al, 2007; Batenburg and Broek, 2008); Ghani et al., 2008). These plans share several similar motivations and reasons for the implementation of medicinal information systems. These include: reduction of medication errors, better productivity, and financial savings.

At the same time the technology developed for managing document has significantly developed. However this new technology based on Semantic Web (Daconta et al., Davies et al., 2002) is not yet deployed in managing medicinal information systems. This is regrettable since through this technology many of the goals of the medicinal information systems could be achieved in an elegant way.

However, during the past few years several organizations in the healthcare sector have produced standards and representation forms using XML. For example, patient records, blood analysis and electronic prescriptions are typically represented as XML-documents (Dolin et al., 2001; Jung, 2005; Puustjärvi and Puustjärvi, 2006; Bobbie et al., 2005). This generalization of XML-technologies sets a promising starting point for the management of medicinal documents. However, the introduction of XML itself is not enough but also many other XML-based technologies (Harold and Scott Means, 2002)

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have to be introduced in order to alleviate the complexity of managing medicinal information (Lin and Hsieh, 2006; Raisinghani and Young, 2008).

We have investigated the management of medicinal knowledge in pharmacies. It has turned out that the volume of information coming in from a variety of information sources such as pharmaceutical companies, medicinal wholesalers, social insurance institutions and other authorities is increasing all the time. Further, the various formats such as paper, fax, email, and a wide variety of multiple electronic media formats are still complicating the information management.

In order to alleviate this problem we have investigated semantic exchange of pharmaceutical information between medical information systems. By semantic exchange we refer to the ability that the communicating parties can unambiguously (based on medicinal ontologies) interpret the exchanged messages.

In order to alleviate this problem, we have introduced the notion of semantic frames, which are included in incoming XML-documents that are sent by other medical organizations to pharmacies. Semantic frames are presented in RDF, and they indicate how the document (medicinal instruction) relates to the ontologies and taxonomies of the pharmacy system. Hence, based on the semantic frame, the integration of the document to the knowledge base can be automatically done. This, however, requires that the healthcare organizations that send the medicinal documents and pharmacies which receive the documents have to commit to the same medicinal ontologies, i.e., use the same vocabulary in specifying and interpreting the semantic frames.

Further, our used ontology models the relationships of the incoming documents and the daily duties in pharmacies, and hence the integration of the documents and daily duties can be also automatically done. The gain of this approach is that medicinal instructions are provided just-in-time, and tailored to their specific needs.

The rest of the paper is organized as follows. In Section 2, we give a motivating example of the problems we have encountered in pharmacies in managing the incoming information flows. Then, we consider the way incoming information should be managed in knowledge centric organizations. In Section 3, we consider the role of medicinal ontologies and taxonomies in managing documents. We first consider the annotation of medicinal instructions by medicinal taxonomies. Then we present our used medicinal ontology, which incorporates documents (medicinal instructions) and the dispensation of medicinal products as well as their relationships.

In Section 4, we consider semantic frames from technical point of view. We first present the SOA-architecture, where the exchange of semantic frames takes place, and then we illustrate how semantic frames are expressed in RDF, and how they are incorporated in SOAP-messages. Finally, Section 5 concludes the paper by discussing the advantages and critical issues of our presented approach.

2 MOTIVATING EXAMPLE

A significant problem in pharmacies is that there are no commonly agreed practices for managing incoming information. The information management is more or less haphazard. On the other hand, it is well known that this is also the case with many other organizations. However, in pharmacies, the incoming information is more critical in the sense that it has direct dependencies on patients' healthcare.

As an example, consider the activity where a pharmacist dispenses drugs to the customer and generates a dispensation note. This operation may give rise for many kinds of additional announcements for the customer. For example:

- The pharmaceutical company may have informed pharmacies that the shape of the tabs has changed, the size of package is changed, or the consistency of the drug has changed.

- Medicinal wholesalers may have informed of the forthcoming changes on certain medicinal products.

- Social insurance institutions may have informed the pharmacy of the changes concerning the refunds of the dispensed drug.

- Healthcare authorities may have informed the pharmacy about the changes concerning the generic substitution of the dispensed drugs. In addition, healthcare authorities may have set restrictions on physicians' rights for prescribing certain drugs or dispensation of certain drugs for certain patients may be forbidden.

The information of such changes is crucial for the customer. However, due to the huge amount of such incoming information there is no hope that the pharmacist can ensure that she or he has transmitted all the relevant information to the customer.

Even though all the incoming information were stored in pharmacy's information system the problem still remains, as the relevant information and its integration into daily duties are not specified in a machine understandable form. On the other hand, as the various systems are independently developed, built based on proprietary solutions, developed in piecemeal way, and tightly coupled through ad hoc means, there is no easy way to develop solutions that require the interoperability of the various systems.

It is well known that these kinds of problems can be avoided in knowledge centric organizations (Davies et al., 2002; Antoniou and Harmelen, 2004). By the term knowledge centric organization we refer to the organization which incorporates Semantic web technologies in information modelling, presentation, storing and retrieval.

Storing a document in the knowledge base includes the following steps:

1. Mark up the information with XML using a relevant XML-Schema.

2. Annotate the information (annotations specify how the connections to organization taxonomies and ontologies can be done).

3. Integrate the information to organizations ontologies.

4. Store the information in an application with a Web service interface. If this is a new Web service, it should be registered in the organization's registry, along with its taxonomy classification.

This kind of management of incoming documents and their associations with organizations taxonomies and ontologies allows effective search and querying functionalities.

A problem, however, is that annotating the documents by appropriate taxonomies and ontologies (i.e., step 2) has turned out to be hard as there are no simple way for automating the annotation. In our approach this problem is avoided as we assume that the sender (creator) of the documents has already annotated the document as it has relevant information to make the annotation. This however, requires that the communicating parties commit to the same medicinal ontologies and taxonomies with respect to the exchanged documents.

We next consider the medicinal taxonomies and ontologies on which our solutions are based on.

3 MEDICINAL TAXONOMY AND ONTOLOGY

3.1 Medicinal Taxonomy

In order to standardize semantic metadata specific taxonomies are introduced in many disciplines.

In general, taxonomy is a way to classify or categorize a set of things into a hierarchy (Daconta et al., 2003). It is a tree like structure consisting of a root and branches where each branching point (i.e., a node) and leaf is an information entity. In the context of information technology taxonomy is generally understood as the classification of information entities in the form of a hierarchy, according to the presumed relationship of real-world entities that they represent.

The logic behind taxonomy is that when one goes up the taxonomy toward the root, the information entities become more general, and respectively when one goes down towards the leaves the information entities become more specialized. To illustrate this, a simply taxonomy of medicinal groups is presented in Figure 1. The idea behind this classification is that the medicinal instructions can be annotated by the metadata items (the branching points and the leaves) represented in the tree.

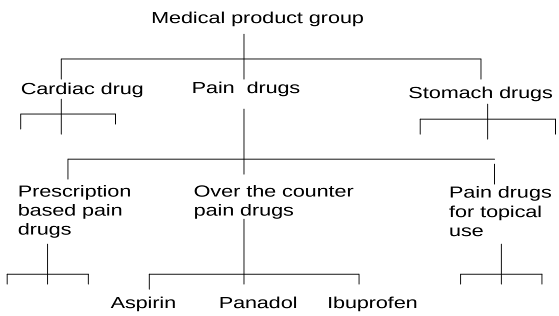

Figure 1: A simple Medical product group taxonomy.

For example, a reason for missing many relevant documents in keyword based searching is that the keywords used with queries and documents metadata descriptions are not standardized by appropriate taxonomies, e.g., a document may be annotated by a keyword “over the counter drug” while a user uses keyword “self-care drug” in searching the information.

3.2 Medicinal Ontology

The term ontology originates from philosophy where it is used as the name of the study of the nature of existence (Gruber, 1993). In the context of computer science, the commonly used definition is “An ontology is an explicit and formal specification of a conceptualization” (Antoniou and Harmelen, 2004). So it is a general vocabulary of a certain domain. Essentially the used ontology must be shared and consensual terminology as it is used for information sharing and exchange. On the other hand, ontology tries to capture the meaning of a particular subject domain that corresponds to what a human being knows about that domain. It also tries to characterize that meaning in terms of concepts and their relationships.

Ontology is typically represented as classes, properties attributes and values. So they also provide a systematic way to standardize the used metadata items. Metadata items describe certain important characteristics of their target in a compact form (Baeza-Yates and Ribeiro-Neto, 1999). The metadata describing the content of a document (e.g., an electronic prescription) is commonly called semantic metadata. For example, the keywords attached to many scientific articles represent semantic metadata

Each ontology describes a domain of discourse. It consists of a finite set of concepts and the relationship between the concepts. For example, within electronic prescription systems patient, medicinal product, and e-prescription are typical concepts. These concepts and their relationships are graphically presented in Figure 2, where ellipses represent classes and boxes represent properties.

The ontology of Figure 2 includes for example the following information:

- Taxonomy item is a class, and a parent item may be associated to a taxonomy item. Hence, we can model a taxonomy (a hierarchy of concepts) by the medicinal ontology.
- Dispensation is a class meaning that each instance of the class is stored in the knowledge base. (Semantically a dispensation is a purchase of a prescription based medicinal product, i.e., a business transaction in a pharmacy). Dispensation is related to an e-prescription, which is related to a medicinal product. Further an e-prescription relates to a patient and physician.
- Instruction is a class, and an instruction may replace another instruction. Further, an instruction may be related to medicinal product, patient or physician.

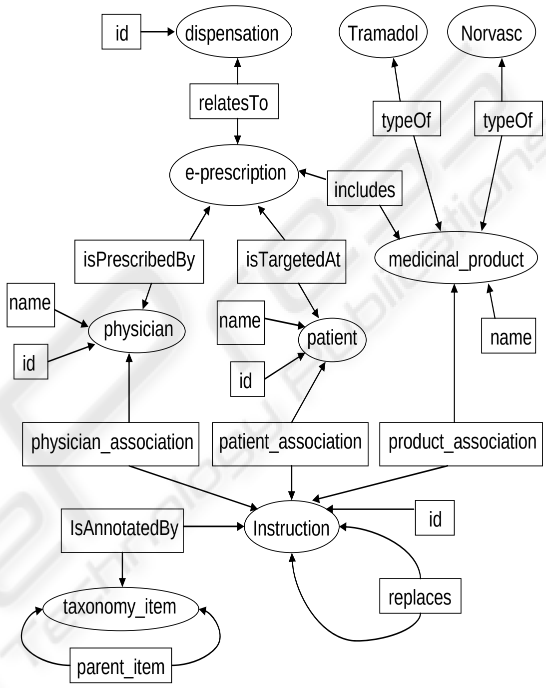

Figure 2: A medical ontology.

A significant point in our used medicinal ontology is that it indicates the possible relationships of the class dispensation and class instruction. Hence, in dispensation activity we can query whether a given dispensation relates to one or more instructions. And most importantly, such a query can be automatically generated within each dispensation activity, and in the case of non empty result, the relevant instructions are shown to the pharmacist. It is also possible to visualize the instructions by using Semantic web technologies as proposed in (Puustjärvi and Puustjärvi, 2008).

4 REPRESENTING SEMANTIC FRAMES

Our used architecture is based on Service Oriented Architecture (SOA) (Singh and Huhns, 2005). It provides flexible methods for connecting pharmacy systems to the other relevant systems (Figure 3).

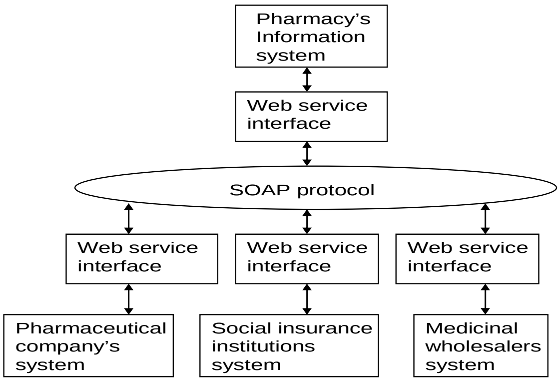

Figure 3: The interaction of medicinal information systems.

We now illustrate how we can send the medicinal intructions as well as their semantic frames by the SOAP protocol.

SOAP was orginally intended to provide networked computers with remote-procedure call services written in XML. It has since become a simple protocol for exchanging XML-messages over the Web.

A SOAP-message is comprised of a SOAP header, SOAP envelope and SOAP body which contains the application-specific message that the backend application will understand. As illustrated in Figure 4, we incorporate our used semantic frame and the instruction in the SOAP body.

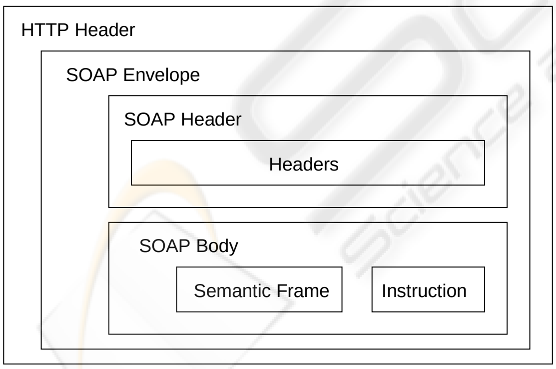

Figure 4: Incorporating a semantic frame in a SOAP message.

An example of our used SOAP-message is presented in Figure 5, where the semantic frame is an RDF-description. The namespaces “mo” and “to” specify the used ontology and taxonomy, respectively. The semantic frame indicates that the instruction “The shape of the tablet has changed” is an instance (type) of class “instruction”. Further, the description indicates that the product_association of the instruction is Tramadol. In addition, the Instruction is annotated by the taxonomy “medicinal product group” by the keyword “Prescription based pain drugs”.

```
<SOAP-ENV: Envelope
  xmlns:SOAP-ENV=“http://schemas.xmlsoap.org/soap/envelope/”
  SOAP-ENV:encodingStyle="http://schemas.xmlsoap.org/soap/encodig/">
    <SOAP-ENV:Body>

      <sematic-frame>
       <rdf:RDF
          xmlns : rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
          xmlns : xsd="http://www.w3.org/2001/XMLSchema#"
          xmlns : mo=“http://www.lut.fi/ontologies/medical-ontology#”
          xmlns : mt=“http://www.lut.fi/ontologies/medical-taxonomy#”>

          <rdf:Description rdf:about=”instruction_123”>
             <rdf:type rdf:resource=“&mo;instruction”/>
             <mo : product _association>Tramadol</mo : recipient>
             <to : medicinal_product_group>
                Prescription_based_pain_drugs
             </to : medicinal_product_group>
          </rdf : Description>
        </rdf:RDF>
      </semantic-frame>

       <instruction>
          <comment> The shape of the tablet has changed </comment>
       </instruction>

    </SOAP-ENV: Body>
</SOAP-ENV: Envelope>
```

Figure 5: A SOAP-message including a semantic frame and an instruction.

5 CONCLUSIONS

Medicinal knowledge is expanding every day. As a result neither the pharmacists nor other workers in the health care sector can keep up without the help of modern information and communication technology. We have considered this problem in the case where a pharmacist dispenses drugs to the customer and generates a dispensation note.

The dispensation may require a variety of relevant announcements for the customer. However, due to the huge amount of such incoming information there is no hope that the pharmacist can ensure that she or he has transmitted all the relevant information to the customer.

In order to alleviate this problem we have introduced the notion of semantic frames, which are included in incoming XML-documents that are sent by other medical organizations to pharmacies. Semantic frames specify how the incoming document (medicinal instruction) relates to medicinal ontologies the integration of the document to the knowledge base can be automatically done.

Further, as the used medicinal ontology models the relationships of the incoming documents and the daily duties, the integration of the documents and daily duties can be automatically done. The gain of this integration is that medicinal instructions can be provided just-in-time, and tailored to their specific needs.

An essential prerequisite of our introduced approach is that the communicating commit to the same medicinal ontologies, i.e., use the same vocabulary in specifying and interpreting semantic frames. This is a critical issue with our approach. The problem here, as well as with any model that is based on Semantic web technologies, is that the creators of the documents (instructions) are burdened with generating semantic frames. However, the generation of semantic frames can be automated by using the tools developed for the Semantic web.

On the other hand, the introduction of a new technology is also an investment. The investment on new ICT-technology includes a variety of costs including software, hardware and training costs. Training the staff on semantic web technology is a big investment, and hence many organizations like to cut on this cost as much as possible. However, the incorrect usage and implementation of a new technology, due to lack of proper training, might turn out to be more expensive in the long run.

Anyhow, the only way to evaluate definitely our proposed approach of using semantic frames is to implement the system in the case of real applications, i.e., in the environment comprising of several pharmacies and medicinal organizations.

REFERENCES

Antoniou, G., Harmelen., F., 2004. *A semantic web primer.* The MIT Press.

Baeza-Yates, R., Ribeiro-Neto, B., 1999. *Modern Information Retrieval*. Addison Wesley.

Batenburg, R., Van den Broek, E. (2008) *Pharmacy information systems: the experience and user satisfaction within a chain of Dutch pharmacies,* International Journal of Electronic Healthcare. Vol. 4, No.2 pp.119-131.

Bobbie, P., Ramisetty, S., Yussiff, A-L., Pujari, S. (2005) *Desgning an Embedded Electronic_prescription Application for Home_Based Telemedicine using OSGi Framework*. Available at: http://cse.spsu.edu/pbobbie/SharedFile/NewPdfs/eRx-Final2Col.pdf

Daconta, M., Obrst, L., Smith, K. (2003) *The semantic web*. Indianapolis: John Wiley & Sons.

Davies, J., Fensel, D., Harmelen, F., 2002. *Towards the semantic web: ontology driven knowledge management.* John Wiley & Sons.

Dolin, R.H, Alschuler, L., Beerb, C., Biron, P.V., Boyer, S.L., Essin, D., Kimber, E., Lincoln, T., Mattison, J.E. (2001) *The HL7 Clinical Document Architecture.* J. Am Med Inform Assoc, Vol. 8 No.6, pp. 552-569.

Dwivedi, A., Bali, R.K., Wickramasinghe, N., Naguib, R. (2007) *How workflow management systems enable the achievement of value driven healthcare delivery.* International Journal of Electronic Healthcare, Vol. 3, No.3 pp.382-393.

Ghani, M., Bali, R.K., Naguib, R., Marshall, I.M., Wickramasinghe, N.S. (2008) *Electronic health records approaches and challenges: a comparison between Malaysia and four East Asian countries,* International Journal of Electronic Healthcare,Vol. 4, No.1 pp.78-104-77.

Gruber, T. R., 1993. *Toward principles for the design of ontologies used for knowledge sharing.* Padua workshop on Formal Ontology.

Harold, E., Scott Means W. (2002) *XML in a Nutshell*. O'Reilly & Associates.

Hyppönen, H., Salmivalli, L., Suomi, R. (2005) *Organizing for a National Infrastructure: The Case of the Finnish Electronic Prescription.* In Proc. of the 38th Hawaii International Conference on System Sciences.

Jung, F. (2005) *XML-based prescription drug database helps pharmacists advise their customers*. Available at: http://www.softwareag.com(xml/aplications/sanacorp.htm.

Lin, B., Hsieh, C. (2006) *Critical factors for assessing service quality of online pharmacies: a research framework.* International. Journal of Electronic Healthcare, Vol. 2, No.4 pp.398-414.

Puustjärvi, J., Puustjärvi, L. (2006). *The challenges of electronic prescription systems based on semantic web technologies*. In Proc. of the 1st European Conference on eHealth, pp. 251-261.

Puustjärvi, J., Puustjärvi, L. (2008) *Using semantic web technologies in visualizing medicinal vocabularies.* In the proc of the IEEE 8th International Conference on Computer and Information Technology.

Raisinghani. M.S. , Young, E. (2008) *Personal health records: key adoption issues and implications for management,* International Journal of Electronic Healthcare. Vol. 4, No.1 pp.67-77.

Singh, M., Huhns, M. (2005) *Service Oriented Computing: Semantics Proceses, Agents*. John Wiley & Sons.