Authoring case based training by document data extraction

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Abstract

Background: Modeling is the bottleneck to successful implementation of knowledge management systems. In this paper, we propose an evolutionary approach to modeling based upon word processing documents and we describe the tool Phoenix providing the technical infrastructure.

Methods: We applied our approach and software system to authoring of medical case based training systems. So far, authors needed to either hand-code the content (usually as HTML) or to use highly sophisticated authoring systems which require instructions and experience to master the complex systems. With our approach we carry further the ideas Felciano and Dev put into practice in their system Short Rounds [4]. They only presented pre-existing documents as an electronic patient record. Following our approach of evolutionary modeling, authors annotate documents to build fully flavored diagnostic training cases [5].

Results: For our training environment d3web.Train1 [6,7], we developed a tool to extract case knowledge from existing documents, usually dismissal records, extending Phoenix to d3web.CaseImporter [8]. Independent authors used this tool to develop training systems e.g. in rheumatology, gastroenterology, and cytology, observing a significant decrease of time for settling-in (from several month down to 1 hour) and a decrease of time necessary for developing a case (down to 4-6 hours) [9].

Conclusions: This paper describes the general approach and provides an in-depth analysis of the document parsing engine (Phoenix) 2. To generalize the success of d3web.CaseImporter, we conclude by sketching further

1http://www.d3webtrain.de
2Phoenix is available under LGPL open source license from https://sourceforge.net/projects/phoenix-ie/
existing applications of Phoenix, including a method to populate the expert system d3web\(^3\) / Assist\(^4\) and extensions still to come (e.g. for populating the Semantic Web [10]).

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1 Motivation

Phoenix is a rule-based extraction engine to transform XML documents to arbitrary output formats. Our target developing Phoenix was to “compile” medical training cases, particularly for d3web.Train, from Word or Open Office documents.

By building upon well known tools and by re-using existing documents, we seek to reduce authors’ efforts both for learning and actual modeling.

Following an evolutionary approach, authors alter and enhance existing content (dismissal records) step-by-step to model the desired content (training cases) [8, 11]. For example, an author anonymizes observations (names, locations, dates), re-formats the document to enable automatic parsing, adds introduction and conclusion, formulates questions and provides feedback knowledge.

As experience shows, we succeeded in our goals to reduce learning time and authoring effort [9]. This led to an increasing popularity among authors, since they can easily provide case-based supplements to lectures.

However, Phoenix is by design a general-purpose tool and is used e.g. for populating xml content management systems and knowledge based systems\(^5\).

First, we introduce Phoenix in high-level overview, going into details in the following sections. The second section analyzes the Phoenix information extraction algorithm, followed by an in depth look to the extension mechanisms necessary to process arbitrary content and store the information into the desired format. In addition, we show how to store the information extracted to XML back again. After that, we describe syntax and semantics of the Phoenix grammar, followed by the API definition. The paper closes with a look at existing Phoenix applications apart from case authoring and a lookout on features to come.

\(^3\)http://www.d3web.de

\(^4\)http://www.knowit-software.de

\(^5\)E.g. for Assist, http://www.knowit-software.de
2 Description

Phoenix is a java-based engine to be extended in order to match concrete requirements. Figure 1 shows the architecture of Phoenix. As a rule-based extraction engine, Phoenix is initialized from a rule set. An user object holds the information extracted, and together with the document is input to Phoenix. To be applicable to different domains, Phoenix provides two extension mechanisms: Selectors to read information from the document and actions to process and store the information to the user object.

![Figure 1: Phoenix architecture.](image)

Phoenix processes arbitrary XML documents as input data. However, Phoenix' main purpose is to process documents in Star Office/Open Office or MS Word format, e.g. discharge letters used for case authoring. Star Office/Open Office .sxw documents essentially are zipped XML documents, so Phoenix accesses these very easily. Phoenix is to natively support the Open Document Standard in future releases.\(^6\) Microsoft Word documents are converted to .sxw automatically, using Open Office as a conversion server. Phoenix is also able to process HTML documents by using JTidy\(^7\) as XML parser.

Phoenix processes XML input documents as DOM\(^8\) trees rather than as character input stream. However, processing does not work on single DOM tree nodes, but on blocks – node collections specified by the rule set. A block thus is a document fragment with all children matching certain criteria. Each rule set defines one or more block types, each specified by an XPath expression, a starting condition (based upon selectors)

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\(^6\)OpenOffice document format is basis for the Open Document Format for Office Applications, an OASIS standard supported by StarOffice, OpenOffice, KWord and hopefully by future versions of Microsoft Word.

\(^7\)[http://jtidy.sourceforge.net](http://jtidy.sourceforge.net)

\(^8\)DOM: Document Object Model, [http://www.w3.org/DOM/](http://www.w3.org/DOM/)
and a grouping expression. Each block type defines a set of rules applied to all blocks of this type identified in the document. These rules fire on a block, if the rule’s condition (again based on selectors) meets the block’s content. Upon firing, the rules activate an action or recursively start another rule set on that block.

We decided against XML documents as premium output. Instead, actions may alter the user object dependent on the block’s content. First, this API-level access to arbitrary user objects enable the use of pre-existing libraries for knowledge representation, providing consistency checks, capsulation, and individual persistence. Second, the more general concept of actions provides a more powerful processing: Direct generation of XML makes it hard to re-structure information once written based upon information parsed later on. However, XML output is supported as a feature (see below) to provide an easy to use transformation output format.

After Phoenix finished parsing a document, the user object is set up with all the information from the document. One can now use this object, e.g. by storing the data to a persistent representation.

3 Algorithm

Phoenix starts processing based upon an `org.w3c.dom.Node` representing the input document and a `java.lang.Object` as user object. Utility methods provide transparent access to .sxw, .doc, and .html documents.

Basis for the parsing process is a `rule set`, providing a set of `block type` definitions. Each block type is specified by an `XPath expression`, a `starting condition` and a `grouping expression`. First, based upon these criteria, minimal `blocks` are generated by Phoenix: For each block type, document nodes matching the XPath expression are evaluated against the corresponding starting condition. If this starting condition is met, a minimal block is created.

A `condition` either is a terminal condition (one of `Exists`, `IntEquals`, `TextEquals`, `TextContains`, `TextStartsWith`, `TextEndsWith`, `TextMatches`, or `ParagraphStart`) or a non-terminal condition (one of `and`, `or`, `not`, or `min-max`). Each terminal condition is configured with a selector (see 4.1); some require comparison values, e.g. `TextEquals`. A condition is checked against a block and returns a Boolean value. This return value is true if and only if the selector matches the content returned by the selector.

Conditions are not only used for starting conditions, but also for grouping or end conditions, and action conditions (see below).

In a second phase, the minimal blocks are expanded according to the corresponding block type’s grouping

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9The list of terminal conditions matches the current needs. It can be extended easily to reflect future requirements.
expression. This may be one of NONE, GROUPING_EXPRESSION, END_EXPRESSION, and NEXT_BLOCK. Both
GROUPING_EXPRESSION and END_EXPRESSION require an XPath expression.

A NONE-grouping does not expand the minimal block. These blocks thus contain a single DOM node. A
GROUPING_EXPRESSION adds the sequencing siblings of the block’s starting node, if it matches the XPath
specified. Vice versa, END_EXPRESSION adds all siblings as long as they do not match the XPath provided.
NEXT_BLOCK as grouping type expands the block up to the beginning of the next block – this grouping type
is the reason for the two-phase block construction process.

For each block Phoenix checks all rules defined by this block’s type. Rules are condition, action, rule set
triples, where either action or rule set or both may be set. If the condition is met by the block, the action
(see §4.2) fires and the rule set is applied to this block’s content.

These inner rule sets optionally specify pre- and post actions to switch the user object for the scope of this
inner rule set. Therefore, the pre-action creates and returns a new user object. If no pre-action is given,
the rule set inherits the knowledge container object. After inner rule set processing is finished, post action
post-processed the extracted information and writes back the local user object to the original user object.
After Phoenix finished traversing the document, the user object given is filled with information extracted.
The user object then can be manipulated in arbitrary ways, e.g. stored in a database.

4 Expansion mechanisms

To allow Phoenix to fit into multiple environments, it provides flexible mechanisms for input content
selection (selectors) and for writing result representation (actions). Selectors are to be used in any
conditions (rule set starting conditions, grouping expressions, and rule conditions) or inside of actions. An
action is part of a rule as defined above.

4.1 Selectors

Generally, selectors are referenced by their class and must be implementations of the interface
de.knowit.phoenix.ruleEngine.Selector. This interface requires a single get-method. For a given
block, a selector’s get-method returns an org.w3c.dom.Node. This Node usually is a single node or a
subset (as org.w3c.dom.DocumentFragment) from the block’s contents. But, since one is free to implement
arbitrary get-methods, a selector might also return information associated to the block, e.g. style
information, or generated information, e.g. Date and Time.

To provide a flexible mechanism, selectors are parameterizable if they implement the Interface
de.knowit.phoenix.ruleEngine.ParameterizedSelector. This is especially useful for the built-in selectors provided by Phoenix (see Table 1). While IdentitySelector and PositionSelector do not require parameters, XPathSelector requires an XPath expression (‘xpath’) and RegExpSelector requires a regular expression pattern (‘regexp’) as parameter.

| Class              | Parameters | Description                                      |
|--------------------|------------|--------------------------------------------------|
| IdentitySelector   | -          | Returns the blocks content as DocumentFragment    |
| PositionSelector   | -          | Returns the blocks position in the list of all blocks. |
| XPathSelector      | xpath      | Returns the first node matching the XPath expression. |
| RegExpSelector     | regexp     | Returns the DOM subtree for which the text matches the given regular expression. Text nodes might be split, structure is cloned as necessary to keep text. |

Table 1: Phoenix's built-in selectors.

If the return value of a selector only depends upon the input block, the first computation of the return value can be cached to improve performance. Phoenix already supports this, if a Selector extends de.knowit.phoenix.ruleEngine.CachedSelector, overwriting the handleGet-method instead of the get-method. To improve management of word processing documents, Phoenix provides convenience methods to read style information – either directly applied to the content or via (inherited) masters. Thus, Selectors can return content based upon the style information associated to the content, e.g. bold text ending with a question mark.

4.2 Actions

Like selectors, Actions are referenced by their class (implementations of de.knowit.phoenix.ruleEngine.Action), configured by parameters (if the action class implements de.knowit.phoenix.ruleEngine.ParameterizedAction), and a selector (if de.knowit.phoenix.ruleEngine.ActionWithSelector is implemented) as a special kind of parameter. If a rule is activated, the perform-method of its action is called, receiving the actual block and the user object as parameters. In addition, a logger is given, so that all activities can be logged using the java logging API.

Besides the Trace-action (de.knowit.phoenix.actions.Trace), which writes information to standard output and logs it, there is a predefined action for writing extracted information to a DOM tree. We will focus on this in the next section.
5 Store extracted information to XML

As mentioned above, Phoenix provides the possibility to write extracted data back to XML again. By that way, one can transform semi-unstructured office documents to structured data represented in XML without the need to implement extensions.

For XML data storage, an `org.w3c.dom.Node` must be used as user object, usually an `org.w3c.dom.Document`. A rule set pre action

(de.knowit.phoenix.xmlUserObject.DescendNodePreAction) to locate a node, and an action

(de.knowit.phoenix.xmlUserObject.SetNodeAction) to set a node value are provided by Phoenix. Both actions require two parameters: ‘path’ and ‘overwrite’.

Path is in XPath, a subclass of XPath: It denotes a sequence of Nodes, separated by a ‘/‘-character. An attribute node is characterized by an ‘@’ sign and may only be the last node in a path, e.g. /organization/person/@id.

`DescendNodePreAction` selects the node specified by path as new user object. Therefore, it creates new Nodes if overwrite is true. Otherwise, existing nodes matching the XPath expression are re-used, new nodes are created as necessary. For `DescendNodePreAction`, path must end in an element reference.

`SetNodeAction` also takes a selector – if no selector is given, `SetNodeAction` acts like an `IdentitySelector` was given. Dependent on the node type of the last path element, `SetNodeAction` performs: If the last path element is an attribute, this attribute’s value is set to the text of the node returned by the given selector. If the last path element is an element node, the node returned by the selector is added as child to that node.

6 Rule Set Definition

Phoenix usually is running against many documents sharing a static common structure. Therefore, each application’s grammar changes only little over time. This allows for manual grammar modeling, providing maximum flexibility.

Phoenix defines rule sets by XML documents according to the Phoenix-XMLSchema. Each rule set document provides a root node named `RuleSet`. Each `RuleSet` has an ID. Additionally, the `RuleSet` node defines necessary namespaces.

```xml
<RuleSet ID="RS:default"
 xmlns:office="http://openoffice.org/2000/office"
 [...]`

11 http://ki.informatik.uni-wuerzburg.de/~betz/phoenix/
Furthermore, an inner RuleSet-Node may contain pre- and post-attributes, specifying the pre and post rule set actions by class name.

```xml
de.d3web.caseParser.actions.examinations.StartCaseParagraph
```

Each RuleSet-Node comprises any number of block type definitions, where each Block has an ID-attribute, a Definition and a list of Rules.

```xml
<Definition>
  <Start matches="/text:p | /text:h"/>
  <Condition type="and">
    <Condition type="paragraphStart"/>
    <Condition type="exists">
      selector="de.knowit.phoenix.selectors.RegexpSelector"
      selectorParameters="regexp=\s*(.*)\s*:"
    </Condition>
  </Condition>
  <Grouping type="END_EXPRESSION">
    <GroupingExpression
      matches="descendant-or-self::*[contains(text(),'Ende')]"/>
  </Grouping>
</Definition>
```

The matches attribute to start specifies the XPath expression for the block starting node. The condition is given by type, selector (optional) and selectorParameters (optional). Conditions may be nested using the aggregation conditions (and, or, not, minmax).

Grouping may be one of the types specified above, where NONE is expressed by omitting the Grouping tag. Thus, the following grouping tags are valid:

```xml
<GROUPING_EXPRESSION>
  <GroupingExpression
    matches="descendant-or-self::*[contains(text(),'Ende')]"/>
</GROUPING>
```

```xml
<END_EXPRESSION>
  <GroupingExpression
    matches="descendant-or-self::*[contains(text(),'Ende')]"/>
</END_EXPRESSION>
```
Like the items above, rules are attributed with an ID. They share the syntax of Condition given above. Each rule possesses at most one Action tag, specifying the action class, and one RuleSet.

```xml
<Rules>
  <Rule ID="R1">
    <Condition type="contains"
      selector="de.d3web.caseParser.selectors.TitleSelector"
      value="Definition"/>
    <Action class="de.knowit.phoenix.xmlUserObject.SetNodeAction"
      parameters="path=@title;overwrite=false">
      <Source selector="example.selectors.StartingNodeSelector" />
    </Action>
    <RuleSet ID="RS:R1">
      ...
    </RuleSet>
  </Rule>
</Rules>
```

7 **d3web.CaseImporter**

Our main target was to build an application ("d3web.CaseImporter\(^{12}\)") for extracting medical training cases from dismissal records (see [11]). With this application, we proof the concept of evolutionary modeling: Authors of medical training cases re-use existing documents, altering and extending content as needed.

With only little changes, a dismissal record can be transformed into a training case: An author needs to make sure that the document’s layout match the requirements given by CaseImporter. He usually strips unwanted formatting like headers and footers. Also, he ensures headings to be in the correct format: starting a new paragraph, boldfaced and ended by a colon. We chose the format used in most dismissal records, so the need for changes in the document is minimal. The heading for the list of diagnoses must be ‘Diagnosen’. The most important step in this first pass is anonymization: The author must remove any private data, including dates and locations.

After the author performed these steps, he can upload his document to d3web.CaseImporter using a web browser. For each case, CaseImporter provides him with a log of parsing events (indicating possible problems using ‘traffic lights’) and a dump of case contents. Also, the author can directly start his case in d3web.Train.

As students’ pre-knowledge and learning goals require, author extends his case. He adds texts and images for introduction or conclusion and multiple choice questions. He improves presentation by adding images

\(^{12}\)[http://www.d3webtrain.de/author/]
(like x-rays, smears or screenshots of lab data forms) and he subjoins image interpretation tasks. For relating observations to diagnoses, author labels both with the same background color.

From these documents, CaseImporter generates a structured representation based upon d3web’s knowledge model: three terminologies (examinations, diagnoses, and therapies) are populated. Content and tasks related to these terminologies. For example, a diagnose selection task requires the learner to select diagnoses appropriate to a given situation from the terminology. Feedback then compares this selection to the list of diagnoses from the terminology given by the author, respecting even hierarchical relations.

To implement CaseImporter, we developed appropriate selectors, actions, and a rule-set. We used selectors basically as shortcut to simplify rule-set definition and to implement the caching mechanism outlined above: e.g. TitleSelector and ContentSelector separate title and content of a paragraph. Actions write to d3web’s CaseObject and sub-parts, as inner rule sets create and select appropriate user objects (like CaseParagraphs). Only ImageExtraction action extracts an image included in the document to the file system, clipping the picture as necessary.

8 Conclusion

Since Phoenix as a general purpose tool, it is already in use in several projects: As a spin-off project from the case extraction engine, Phoenix parser was integrated into the knowledge modeling environment KnowME to import terminology from text or document files. The knowledge bases created with KnowME are used either in d3web applications or in the consultation system Assist.

Completely separated from our main project, Phoenix is also used to populate a juridical eLearning environment from Word documents.

Future releases of Phoenix will include actions for building Semantic Web ontologies, building on the Jena framework. By this, we will carrying on the evolutionary approach to arbitrary Semantic Web applications, widening the modeling bottleneck.

Experiences show that d3web.CaseImporter matches that goal for medical case based training systems: It was possible to reduce the time for settling-in from months down to an hour. Also, time for developing a single case was reduced, especially when compared to previous approaches to first build a complete diagnostic knowledge base for the domain or to reuse an existing one [12].

This speed-up led to an increasing acceptance of case-based training systems by authors. Now, even

\[http://www.d3web.de\]

\[Assist by knowIT-Software GmbH, http://www.knowit-software.de\]

\[http://jena.sourceforge.net/\]
inexperienced authors are able to develop high-quality cases in a reasonable amount of time, e.g. when preparing a lecture. Training systems built using CaseImpporter are well accepted by students [9].

As Kraemer, co-author of an onkological system, puts it: “The d3web.Train system offers a new and great tool for creating a training program in a reasonable amount of time” [9].

References

1. Bernauer J, Fischer MR, Leven FJ, Puppe F, Weber M (Eds): Rechnergestützte Lehr- und Lernsysteme in der Medizin: Proceedings zum 6. Workshop der GMDS AG Computergestützte Lehr- und Lernsysteme in der Medizin, FH Ulm, 11.-12. April 2002. Aachen: Shaker Verlag 2002.

2. Puppe F, Albert J, Bernauer J, Fischer M, Klar R, Leven FJ (Eds): Rechnergestützte Lehr- und Lernsysteme in der Medizin: Proceedings zum 7. Workshop der GMDS AG Computergestützte Lehr- und Lernsysteme in der Medizin, Universität Würzburg, 3.-4. April 2003. Aachen: Shaker Verlag 2003.

3. Pöppl S, Bernauer J, Fischer M, Handels H, Klar R, Leven J, Puppe F, Spitzer K (Eds): Rechnergestützte Lehr- und Lernsysteme in der Medizin: Proceedings zum 8. Workshop der GMDS AG Computergestützte Lehr- und Lernsysteme in der Medizin, Universität zu Lübeck, 25.-26. März 2004. Aachen: Shaker Verlag 2004.

4. Felciano RM, Dev P: Multimedia Clinical Simulation based on Patient Records: Authoring, User Interface, Pedagogy. Tech. rep., Stanford University Schol of Medicine 1994.

5. Betz C, Puppe F: Formale Beschreibung fallbasierter diagnostischer Trainingssysteme. In Puppe et al. [2] 2003.

6. Hörnlein A, Betz C, Puppe F: Redesign eines generativen, fallbasierten Trainingssystems für das WWW in d3web.Train. In Bernauer et al. [1] 2002.

7. Reimer S, Kneitz C, Tony HP, Schewe S, Hörnlein A, Puppe F: d3web.Train: Erste Evaluationsergebnisse zum Einsatz in der Medizinerenausbildung an der Medizinischen Poliklinik der Universität Würzburg. In Pöppl et al. [3] 2004.

8. Hörnlein A, Reimer S, Kneitz C, Betz C, Puppe F: Semantische Annotierung von Arztbriefen zur Generierung diagnostischer Trainingsfälle. In GI Edition “Lecture Notes in Informatics”, DELFI2004: Die 2. e-Learning Fachtagung Informatik Tagung der Fachgruppe e-Learning der Gesellschaft für Informatik e.V. (GI) 6.-8. September 2004 in Paderborn. Edited by Engels G, Seehused S, Gesellschaft für Informatik 2004.

9. Krämer D, Reimer S, Hörnlein A, Betz C, Puppe F, Kneitz C: Evaluation of a novel case-based Training Program (d3web.Train) in Hematology. “Annals of Hematology” 2005.

10. W3C: W3C Semantic Web. [http://www.w3.org/2001/sw/ (26. 11. 2002)].

11. Betz C, Buscher HP, Hörnlein A, Puppe F, Schuhmann M: Generierung diagnostischer Trainingsfälle aus Arztbriefen. In Pöppl et al. [3] 2004.

12. Reinhardt B: Didaktische Strategien in generierten Trainingssystemen zum diagnostischen Problemlösen. PhD thesis, Bayerische Julius-Maximilians-Universität Würzburg 1999. [Akademische Verlagsgesellschaft, Dissertationen zur Künstlichen Intelligenz, Bd. 234].