UNIVERSITY OF SOUTHAMPTON

Experience Report: Serving *Hypermedia and the Web Online* with HA^{3}L

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Chapter 1

Introduction

HA^{3}L (Hypermedia, Agents and Adaptation using Auld Linky) is an agent-based adaptive hypermedia system developed by Bailey Bailey et al. (2002), which uses existing technology developed by the Intelligence, Agents, Multimedia Group (IAM) in the form of the Southampton Framework for Agent Research (SoFAR) Moreau et al. (2000), the Auld Linky contextual hypermedia structure service Michaelides et al. (2001), and the Fundamental Open Hypermedia Model (FOHM) Millard et al. (2000). HA^{3}L provides *guided tours* of a topic which are adapted according to explicitly set user preferences of *depth*, *modality*, and *length*. Depth represents the level of detail that the user wants to see on the topic, for example, a novice user may select a high level of detail whereas an expert user may select a low level of detail. Modality represents the type of presentation the user wants to see, for example, text or video. Length is a boolean value that indicates whether or not the presented content should be 'kept short'. The content of the guided tour is augmented with generic "glossary" links leading to detailed definitions of selected terms[1]. HA^{3}L also provides implicit adaptation in accordance with its user model, for example, adapting the presentation to make clear to the users the concepts or links which they have already "seen". To demonstrate the capabilities of HA^{3}L, Bailey has constructed a number of adaptive guided tours using information from the field of *rheumatology* (Figure 1.1).

Hypermedia and the Web Lowe and Hall (1999) outlines an engineering approach to the design and management of Web hypermedia applications. The authors wish to create an online resource[2] which complements (rather than merely replicate) the content presented in the book, providing extra material and examples, and which provides adaptive presentations of its content tailored to individual visitors to the site.

The purpose of this report is firstly to briefly recount the experience of understanding the operation of the HA^{3}L framework (using the *Introduction to Rheumatology* example as

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[1] cf. Microcosm's *generic links* Fountain et al. (1990).

[2] For the purposes of this report, this deliverable will be referred to as *Hypermedia and the Web Online*.
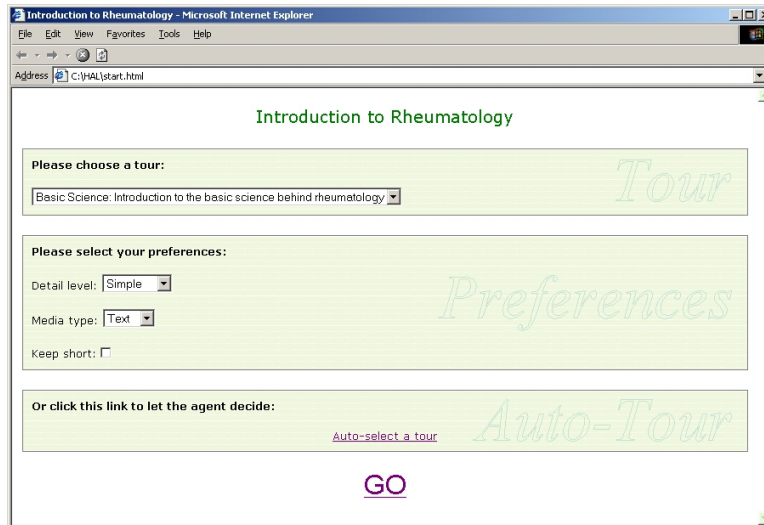
FIGURE 1.1: Choosing a tour and setting user preferences.

a reference), and secondly to describe how the framework has been applied to providing adaptive tours through part of the *Hypermedia and the Web* book. The suitability of the framework for serving an adaptive *Hypermedia and the Web Online* resource is also briefly discussed, based on the reported experiences.

Chapter 2

Exploring HA^{3}L and the *Introduction to Rheumatology* Example

HA^{3}L runs within the SoFAR agent framework (Figure 2.1), and consists of three types of agent:

User Model Agent encapsulates characteristics of the user.

Linky Agent provides contextual hypermedia tour structures by acting as an intermediatry between other SoFAR agents and Auld Linky.

User Agent provides adaptive presentation to the user.

These operation of these agents is described in the following sections.

2.1   User Model Agent

The user model agent encapsulates characteristics of the user, by maintaining lists of the following items:

- The items that a user has visited on a tour (in the form of FOHM *data object* IDs, discussed later)

- The *concepts* that a user has seen (each item on a tour may have several associated concepts; a concept may be applicable to more than one item).

3
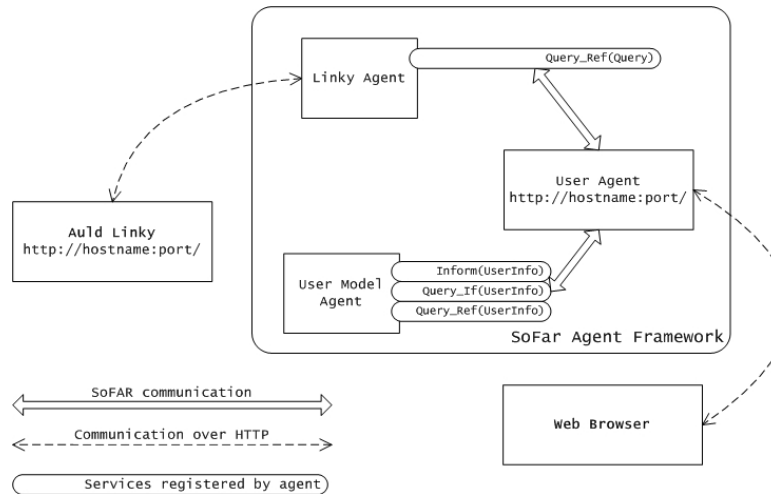
FIGURE 2.1: Basic HA³L architecture.

- The *glossary* items that a user has seen (each item on a tour may have several associated glossary links; a glossary link may be applicable to more than one item).

- The *tours* that a user has seen.

- The *level of detail* at which each tour has been seen.

2.1.1   Contract Summary

The user model agent is able to carry out three contracts within the SoFAR framework, each of which uses the UserInfo predicate (essentially a name/value string tuple to which information about the user can be arbitrarily assigned):

1. `Inform(UserInfo)` — Updates the user model according to the UserInfo predicate. For example, if the UserInfo predicate is the tuple (`visited,dataobject_id`), the user model agent updates the list of items that the user has visited.

2. `Query_If(UserInfo)` — Queries the user model according to the UserInfo predicate. For example, if the UserInfo predicate is the tuple (`glossary,glossary_id`), the user model agent consults the list of glossary items that the user has seen and returns true if the user has already seen the specified item, false otherwise.

3. `Query_Ref(UserInfo)` — Gets the user model according to the UserInfo predicate. For example, if the UserInfo predicate is the tuple (`concept,`) (value unassigned), the user model agent returns an array of UserInfo objects representing all the concepts that the user has seen.

When a session ends, the user model agent serialises the user model. At the beginning of a session, the user model agent checks for the existence of a previously serialised model (loading it if available), allowing user characteristics to be persisted between sessions.

2.2 Linky Agent

The linky agent acts as an intermediary between SoFAR agents and the Auld Linky contextual hypermedia structure service (see also Section 2.4). The linky agent carries out one contract within the SoFAR framework, with the Query predicate. The Query predicate (part of the FOHM object model Millard et al. (2000)) contains a *context* and a *structure*. The Query object is serialised as XML and sent to Auld Linky over HTTP (hostname and port of Auld Linky service configurable by an administrator). Figure 2.2 shows some example Query predicates (in serialised XML form).

In Figure 2.2a, the query matches any FOHM structures in the Auld Linky linkbase that have a *relationshiptype* attribute set to *glossary* (the `missing="variable"` pragma means that any attributes of the association not specified will be assumed to match the query). This query has the effect of retrieving every glossary link from the linkbase.

In Figure 2.2b, the query matches any FOHM structures that have a *relationshiptype* attribute set to *tour*, and a *structure* attribute set to *link*. This query has the effect of retrieving all the tours from the linkbase.

In Figure 2.2c, the query matches the FOHM structure with the unique id *basic_science*, and then prunes the association using the *context* information (illustrated using FOHM graphical notation Millard et al. (2000) in Figure 2.3). In this example, any reference, binding, or data FOHM objects will be pruned if the attached context does not match the constraint imposed by the query (value of *depth* attribute must be less than or equal to 10). The tour structures are actually more complicated than that implied by Figure 2.3, as we shall see in Section 2.4.

2.2.1 Contract Summary

1. `Query_Ref(Query)` — Communicates the serialised Query to Auld Linky over HTTP, parses the result (also represented in XML) returned by Auld Linky into a FOHM Linkbase object, and returns the result.

2.3 User Agent

The user agent receives requests directly from the user via HTTP rather than internal SoFAR communication. The hostname and port on which the user agent listens are configurable by an administrator, and the agent is responsible for presenting adaptive guided tours to the user according to their preferences and the information held by the user model. The user agent uses the services provided by the user model agent and linky agent to achieve this. As such, the user agent is perhaps the most complex agent

```
<query>
  <association missing="variable">
    <relationtype>glossary</relationtype>
  </association>
</query>
```

(a)

```
<query>
  <association missing="variable">
    <relationtype>tour</relationtype>
    <structure>link</structure>
  </association>
</query>
```

(b)

```
<query>
  <association id="basic_science" missing="variable">
    <structure>link</structure>
  </association>
  <context>
    <contextvalue key="depth" state="variable">
      <constraint>\$\_[0]<=10</constraint>
    </contextvalue>
  </context>
</query>
```

(c)

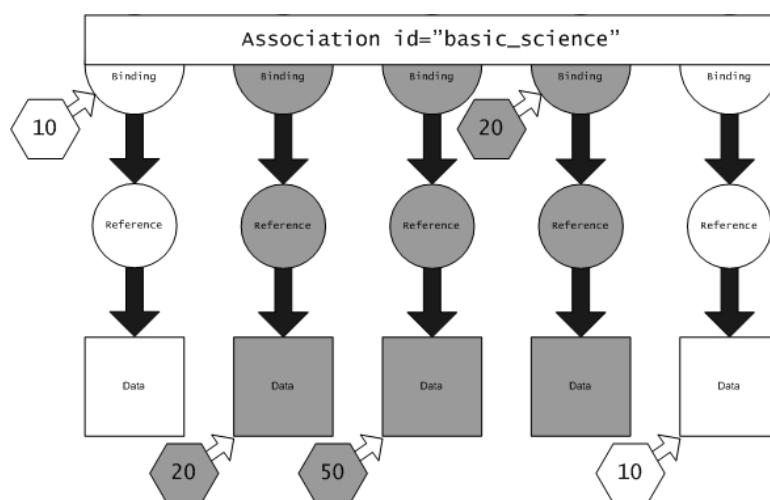FIGURE 2.2: Example queries handled by the Linky Agent (shown in serialised XML form)

FIGURE 2.3: Pruning a FOHM association using context constraints in Query object (Figure 2.2c). The grey *depth* contexts have failed to match the Query context (*depth*<=10), and are therefore pruned from the association.

(in terms of program operation) in the HA³L system, and deserves a more detailed examination.

User requests are sent to the user agent over HTTP from a Web browser. The user agent responds to several requests, summarised below.

- *Lookup* a tour, given user preferences (Section 2.3.1).

- Generate a *table of contents* for the tour (Section 2.3.2).

- Generate the *main content* of a given step in the tour (Section 2.3.3).

- Generate an *infobar* for a given step in the tour (Section 2.3.4).

- Generate a *glossary page* for a given concept (Section 2.3.5).

- *Choose a suitable tour*, based on the user's previous interactions (Section 2.3.6).

2.3.1 Lookup

Example:

```
http://localhost:33333/lookup?
topic=basic_science&depth=10&modality=text&length=short
```

Starts a guided tour, given the id of the chosen tour (*topic*) and user preferences for the tour (*depth*, *modality*, and *length*). This request is initiated by the start page (Figure 1.1). The user agent responds to this request by requesting the specified tour from Auld Linky in the given context. In the *Introduction to Rheumatology* example, *depth* is represented as the numerical value 10 (*Simple*), 20 (*Extended*), or 50 (*Detailed*). If the user selects the *Simple* depth, the guided tour is pruned of any structure that has an associated context value greater than 10. If the user selects the *Extended* depth, the full guided tour is returned (no pruning takes place). The HA³L system therefore provides adaptive tours by *selectively hiding content* according to user preferences.

The user agent constructs a FOHM Query object that encapsulates the selected tour and depth (Figure 2.2c shows the serialised XML form of the FOHM Query object constructed in response to the example URL shown above). For each agent in the framework able to undertake the contract `Query_Ref(Query)` (in the *Introduction to Rheumatology* example, a linky agent undertakes the contract), the user agent receives a FOHM linkbase describing the contextual tour. Provided that a contextual tour could be obtained which matched the user preferences, the user agent builds the start page of the tour, consisting of a page divided into 3 frames (Figure 2.4 and Figure 2.5). Each frame invokes a separate request to the user agent for its content.
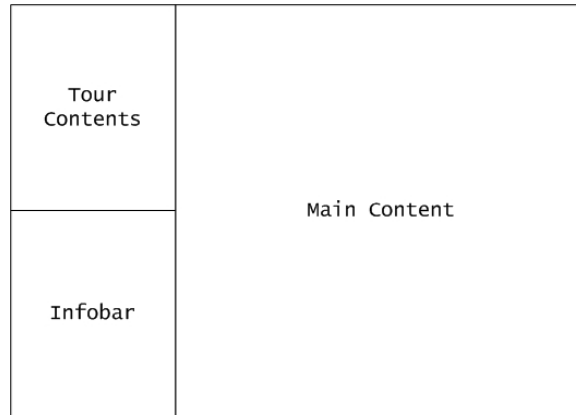
FIGURE 2.4: Page layout generated by lookup request.

The user agent also informs any agents able to undertake the contract `Inform(UserInfo)` of the selected tour id and depth. In the *Introduction to Rheumatology* example, a user model agent undertakes the contract.

2.3.2   Table of Contents

Example: `http://localhost:33333/toc`

Builds a table of contents for the current tour using the cached result from a lookup (see Section 2.3.1). Figure 2.5 shows the the table of contents generated for simple, extended, and detailed tours of the *basic_science* topic.

2.3.3   Main Content

Example: `http://localhost:33333/basic_science/immune_response`

Presents the specified page of the current tour (in the example URL, the page is represented by the FOHM data object with the id `basic_science/immune_response`), with links to the next and previous pages in the tour, links to more detailed information (where appropriate), and inline links to glossary terms (also summarised in the Infobar, see Section 2.3.4).

The user agent queries each agent in the framework able to undertake the contract `Query_If(UserInfo)` to determine whether the user has previously visited the specified page, and to determine the glossary links that the user has previously followed. The user agent also informs any agents able to undertake the contract `Inform(UserInfo)` that the previous page in the browsing history (where applicable) has now been seen by the user. In the *Introduction to Rheumatology* example, a user model agent undertakes both these contracts.

(a)

(b)   (c)
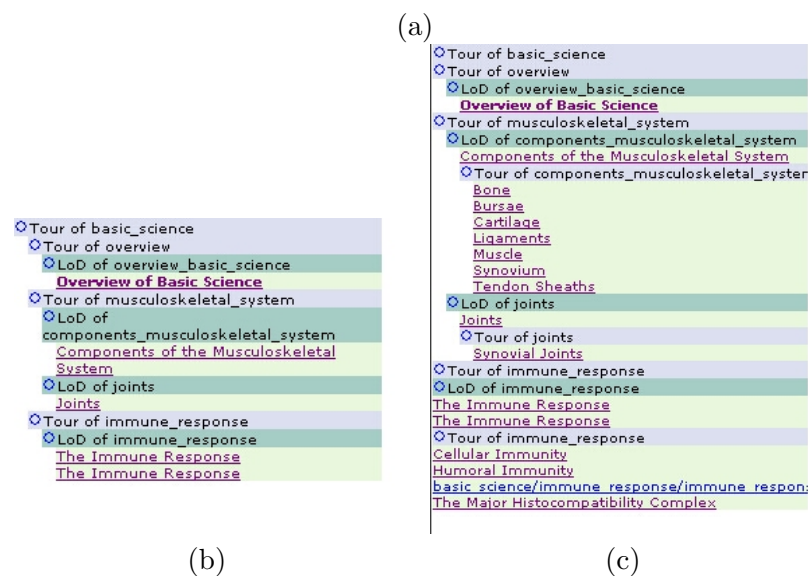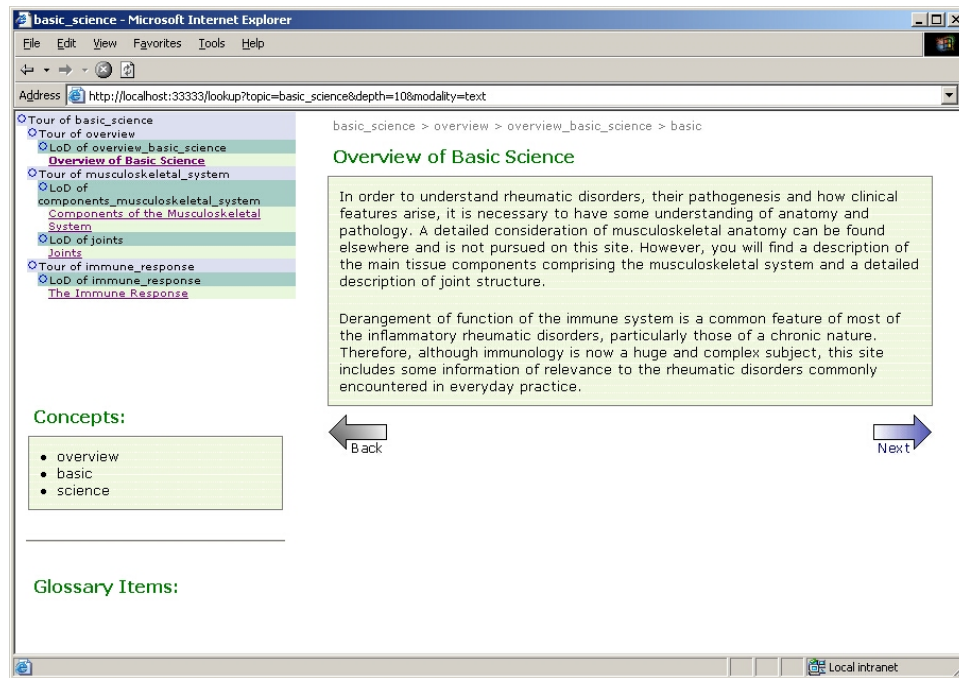
FIGURE 2.5: Start screen for simple tour (a) with detail of table of contents for extended (b) and detailed (c) tours.

If the user *length* preference is set, only the first paragraph of the content is displayed, with a link which expands the text to reveal any further content (Figure 2.6). This preference is currently maintained by the user agent for the duration of a session, rather than managed by agents such as the user model agent, and is set in the static user preferences page shown in Figure 1.1.

If the user *modality* preference is set (this preference is currently maintained by the user agent for the duration of a session, rather than managed by agents such as the user model agent, and is set in the static user preferences page shown in Figure 1.1), and the selected media representation is available for the selected page, the content will be
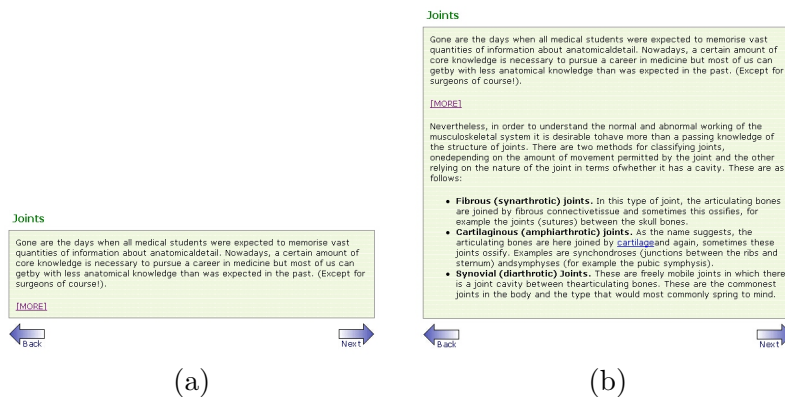
FIGURE 2.6: Main content shown with user length preference set (a). Following the *MORE* link reveals further content (b).
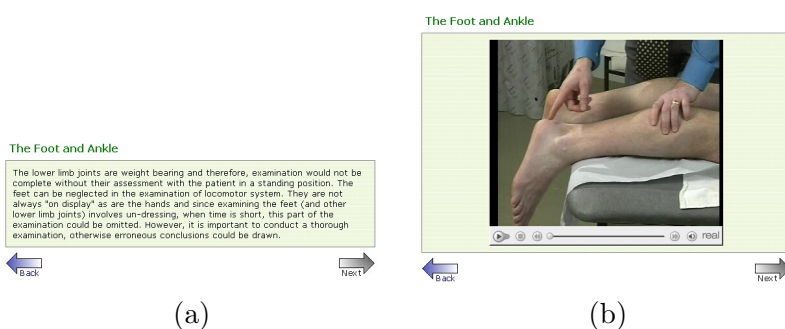
FIGURE 2.7: Main content presented according to user modality preference of text (a) and video (b).

presented according to the user preference (Figure 2.7)[1].

The user agent builds the content page by presenting the title and associated content of the specified data object (using appropriate presentation media). If the presentation medium is text, for each specified glossary item for the data object (see Section 2.4.2), the user agent replaces the first instance of the glossary term in the content with a link to the glossary definition. If the user has previously followed the glossary link, the link is presented in black (rather than the default blue) text to visually distinguish between visited and unvisited links (in effect *hiding* previously visited links). In all cases, the user agent also creates links to the previous and next pages on the tour, relative to the specified page, and also a link to more detailed information where the user depth preference has not caused more detailed pages to be pruned from the tour (see Section 2.3.1).

2.3.4   Infobar

Example: `http://localhost:33333/infobar/basic_science/overview`

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[1] Note that both modalities are available from the table of contents for the tour, but if the user follows the *next* links through the tour, the user modality preference will be used to determine the presentation medium of the next item in the tour (provided alternative presentation mediums are available).
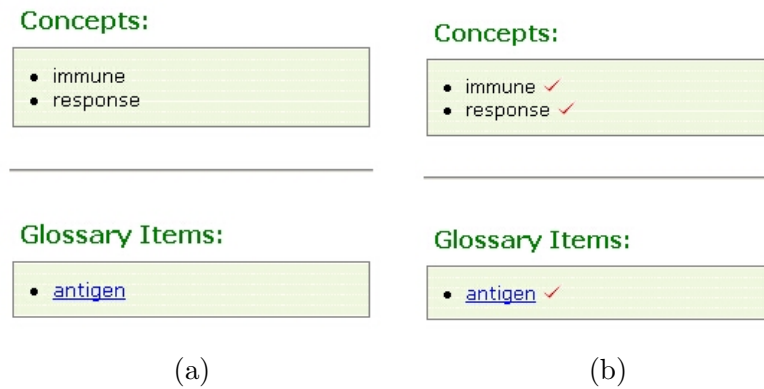
FIGURE 2.8: Infobar presenting new concepts/glossary links (a) and concepts/glossary
links that have been seen by the user before (b).

Summarises the relevant concepts and glossary links for the currently displayed page
(which may be presented using different media according to the user's modality prefer-
ence) of the tour (in the example URL, the currently displayed page is represented by
the FOHM data object with id `basic_science/overview`). Figure 2.8 illustrates the
Infobar.

For each concept, the user agent queries each agent in the framework able to undertake
the contract `Query_If(UserInfo)` (in the *Introduction to Rheumatology* example, a user
model agent undertakes the contract) to determine whether the user has previously
seen a page relating to this concept. If this is the case, the concept is presented in
the Infobar with a "tick" to visually inform the user that the concept has been seen
before (Figure 2.3.4b). If the concept has not been seen before, the user agent informs
any agents able to undertake the contract `Inform(UserInfo)` that the user has now
seen the concept. A similar process is applied to the presentation of the glossary links
(Figure 2.8b).

2.3.5   Glossary Page

Example: `http://localhost:33333/glossaryitem/antigen`

Builds a glossary page for the specified glossary term (in the example URL, the glossary
term is *antigen*). Figure 2.9 shows an example glossary page for the term *antigen*.
Glossary pages are displayed in popup windows when the user clicks a glossary link
from the Infobar or an inline glossary link from the main content.

The user agent informs any agents able to undertake the contract `Inform(UserInfo)`
that the user has now seen the definition of the glossary term. In the *Introduction to
Rheumatology* example, a user model agent undertakes the contract.
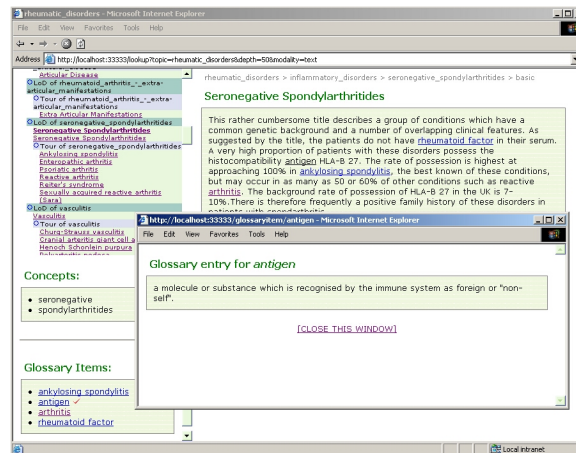
FIGURE 2.9: Glossary definition.

2.3.6 Letting the User Agent Choose a Tour

Example: `http://localhost:33333/choosetour`

Similar to the *lookup* request, but the user agent chooses the tour, based on the user's previous HA³L interactions.

The user agent queries each agent in the framework able to undertake the contract `Query_Ref(UserInfo)` to receive a list of the guided tours (in the form of tour IDs) that the user has previously taken (in this or previous sessions) and the depth at which the user chose to view each tour. In the *Introduction to Rheumatology* example, a user model agent undertakes the contract.

The user agent then chooses at random a tour that the user has not seen before (if all the tours have been seen before, the user agent picks one at random). The user agent determines the depth at which to present the chosen tour by finding the most popular depth in previous tours (for example, if the user has previously seen two tours at *Simple* depth, 1 tour at *Extended* depth, and one tour at *Detailed* depth, the user agent would present the chosen tour at *Simple* depth). If the depth cannot be chosen using this method (for example, the user has not seen any tours), the depth is chosen at random.

The *length* and *modality* preferences retain their default values (length preference unset, modality preference set to "text").

The user agent then proceeds as with a *lookup* request (see Section 2.3.1), constructing a FOHM Query object that encapsulates the selected tour and depth. For each agent in the framework able to undertake the contract `Query_Ref(Query)`, the user agent receives a FOHM linkbase describing the contextual tour. In the *Introduction to Rheumatology* example, a linky agent undertakes the contract. Provided that a contextual tour could be obtained that matched the user preferences assigned by the user agent, the start page of the tour is built.
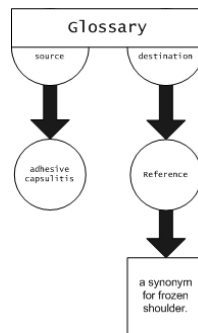
FIGURE 2.10: FOHM glossary link structure.

The user agent also informs any agents able to undertake the contract `Inform(UserInfo)` of the assigned tour id and depth. In the *Introduction to Rheumatology* example, a user model agent undertakes the contract.

2.4 FOHM Structures

In the *Introduction to Rheumatology* example, data for the guided tours presented by HA^{3}L is stored in three separate linkbases (each linkbase describing FOHM structures using an XML representation):

1. `glossary.xml` — decribes the generic glossary links that HA^{3}L uses to augment the information presented in the guided tours.

2. `data.xml` — describes the data content of the tours (equivalent to describing the content of each Web page that the user sees on a guided tour), including the glossary links relevant to the content, the concepts covered in the content, and the context of the content (in terms of *depth* and *modality*).

3. `structures.xml` — connects the data objects defined in `data.xml` as a series of FOHM association structures representing guided tours through the topic.

2.4.1 Glossary Links

Appendix A shows how a glossary link is represented in XML as a FOHM structure (Figure 2.10 illustrates the same link using the FOHM graphical notation).

2.4.2 Guided Tours

In the FOHM representation, guided tours are made up from[2]:

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[2]See Bailey et al. (2002) for further explanation of these terms.

- *Tours* — FOHM associations representing a set of objects designed to be viewed in sequence.

- *Levels of Detail (LoDs)* — FOHM associations associating multiple representations of the same object, ordered within the association from the simplest representation to the most complex.

- *Concepts* — FOHM associations which collect together multiple objects that represent the same conceptual entity, for example, text and video presentations of the same information.

- *Data* — FOHM data objects representing actual content for the tour.

Appendix B shows how a data object is represented in XML. The content that the user sees (provided their preferences match the context specified in the *context* attribute) is stored in the *datacontent* attribute. The *behaviour* attributes are used to list *concepts* and *glossary links* appropriate to the data content.

Appendix C shows how a guided tour is represented in XML as a FOHM structure, illustrated using FOHM graphical notation by Figure 2.11.
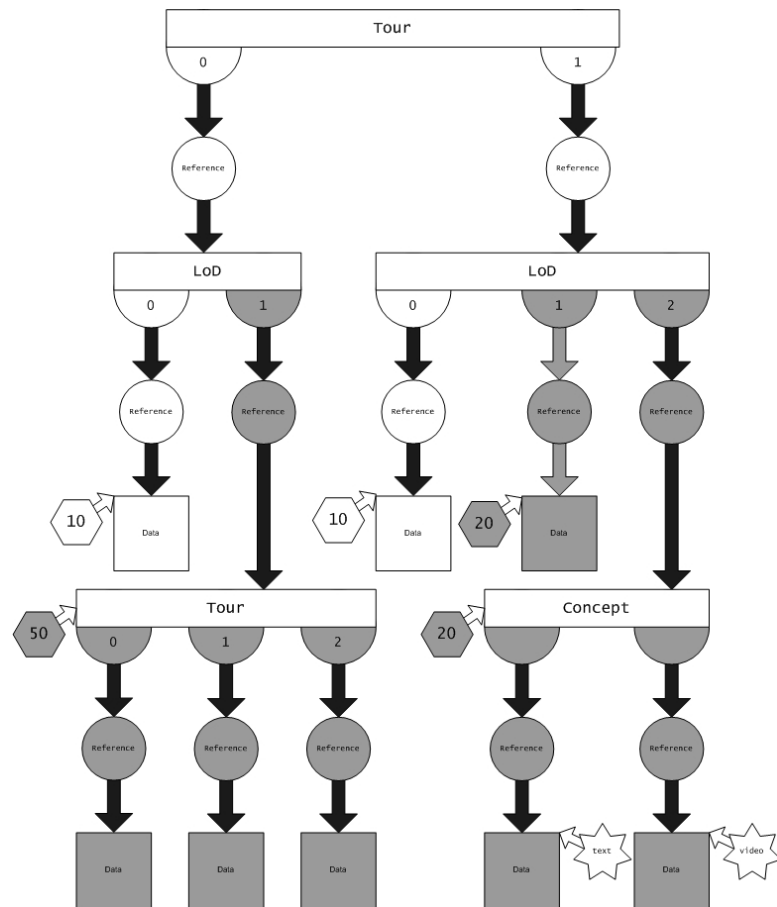
FIGURE 2.11: FOHM tour structure. The structure has been pruned using the Query context constraint (Figure 2.2c). The grey *depth* contexts have failed to match the Query context (*depth*<=10), and are therefore pruned from the tour.

Chapter 3

Serving *Hypermedia and the Web Online* with HA³L

This section describes how HA³L was used to provide an adaptive tour of Chapter 7 ("Development Process") of the *Hypermedia and the Web* book, a chapter that seemed to lend itself particularly well to the tour format as it guides the reader through the steps involved in the hypermedia development process. In this small case study, the content of the book was largely used in an unedited form[1], as the purpose was merely to evaluate the process and suitability of serving content from *Hypermedia and the Web* using HA³L rather than focus on elaborate content editing. This section describes the changes made to the HA³L code to make the adaptive tours more suitable to the presentation of the *Hypermedia and the Web* content, and the process by which the FOHM representations of the tour structure and glossary were constructed.

3.1 Tailoring representation of User Knowledge Level

In the *Introduction to Rheumatology* example, *depth* is represented as the numerical value 10 (*Simple*), 20 (*Extended*), or 50 (*Detailed*). If the user selects the *Simple* depth, the guided tour is pruned of any structure which has an associated context value greater than 10. If the user selects the *Extended* depth, the full guided tour is returned (no pruning takes place). In this example, therefore, the HA³L system provides adaptive tours by *selectively hiding content* according to user preferences.

In the *Hypermedia and the Web Online* experiment, I wanted depth to be explicitly tied to user knowledge level ("I have only a basic knowledge of hypermedia") rather than a statement of preference ("Show me only a simple level of detail") — this seemed a

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[1]It should be noted that one of the stipulations of the *Hypermedia and the Web Online* project is that users should not be able to reproduce the content structure of the paper book from the online version.
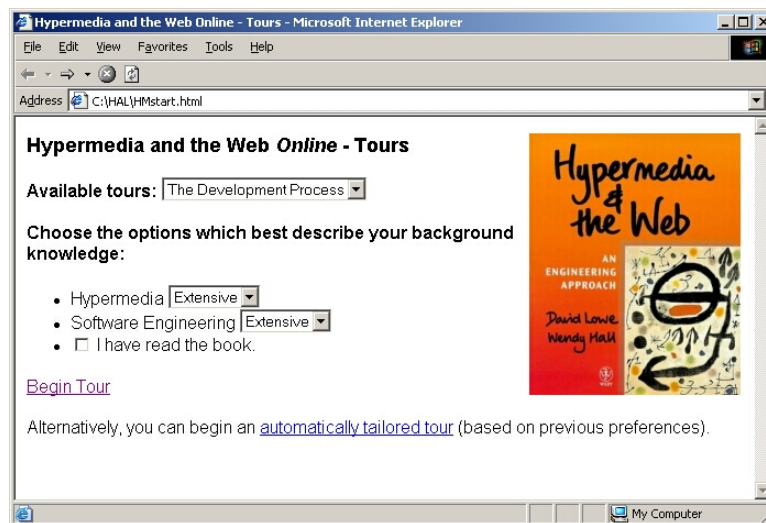
FIGURE 3.1: Choosing a *Hypermedia and the Web* tour and indicating current knowledge .

more natural way for the user to indicate their knowledge of a topic. I also wanted to introduce knowledge about specific topics within the tour. The *Hypermedia and the Web* book brings together information from a variety of disciplines, such as hypermedia, software engineering, design, and management, and may also be used by many different people (students, lecturers, hypermedia designers). To better model user knowledge of these often diverse disciplines, I extended the HA³L code to allow users to indicate their knowledge of more than one topic (in the following examples, the user can indicate their level of knowledge of both hypermedia and software engineering). The *depth* value used by HA³L now encodes several knowledge values as a series of key/value pairs (although *depth* is still stored as a single value in the user model agent).

For example, in Figure 3.1, the user has indicated that their knowledge of both hypermedia and software engineering is *Extensive*, which corresponds to a *depth* preference of `hm_depth=10&se_depth=10` being passed to the user agent (Section 2.3.1). The encoded depth preferences correspond to a *Simple* tour in *Introduction to Rheumatology* example (*depth=10*) — the user has extensive knowledge of the topic and therefore only needs to see a basic level of detail. The 'keep short' preference of the *Introduction to Rheumatology* example has been retained as a further device for the indication of the user knowledge ("I have read the book"), but is still a boolean option, and remains otherwise unchanged.

3.2 Building FOHM Structures

The process of building FOHM structures describing a tour through Chapter 7 of the *Hypermedia and the Web* book (available in HTML format) involved the following steps:

1. Convert *Hypermedia and the Web* HTML pages to skeleton FOHM data objects.

2. Edit skeleton data objects to define concepts, glossary, and context attributes.

3. Create tour structure.

4. Assign depth values to data objects.

5. Create FOHM glossary linkbase.

3.2.1   Converting HTML pages to skeleton FOHM data objects

The first step was to convert the collection of HTML pages making up Chapter 7 into a set of skeleton FOHM data objects (using an XML representation), each data object encapsulating information on a particular topic within the chapter and representing a single page in the guided tour. The chapter was split into seven HTML files, corresponding to each of the major sections of the chapter:

1. Key issues and goals of the chapter

2. Introduction

3. Understanding the project

4. Selecting a product model

5. Selecting a process model

6. Project planning and management

7. Framework for documentation

For each HTML file, the `html2fohmdata` script (Appendix F) extracted each section or subsection heading and its content and created a skeleton FOHM data object. For example, the *Selecting a Product Model* section contained the following subsections:

1. What is a product model?

    (a) Programming language based model

    (b) Screen based model

    (c) Information centered model

2. Selecting and adapting a product model

3. Example

The skeleton data object for the *Information centered model* generated by the script is shown in Appendix D.

Script usage:

```
html2fohmdata < ch7.1.html > data.xml
```

3.2.2   Editing skeleton data objects

The next step involved manually editing the skeleton data objects. This included some minor editing of the content (removing references to other sections, examples and appendices in the book, splitting data objects with large content into two or more data objects, and summarising) and identifying suitable glossary terms and concepts relevant to the content of the data object. Appendix D and Appendix E show the same data object before and after editing.

3.2.3   Creating tour structure

The next step was to identify how the data objects could be presented within an adaptive tour structure. This involved identifying potential FOHM *Tours* and *Levels of Detail* within the chapter. The tour was described using a simple notation (Figure 3.2.3) to facilitate faster editing and rearranging of the tour than would be possible using the complex FOHM representation. The basis for this structure was obtained by extracting the id of each data object created in the previous stages. The `tour2fohmstruct` script (Appendix G) converted this notation into an XML representation of a FOHM tour structure.

Script Usage:

```
perl -n -e "print \"$1\n\" if /<data id="(.*?)">/;" < data.xml > tour


tour2fohmstruct < tour > tour.xml
```

3.2.4   Assigning depth values

After creating the tour structure for the chapter, "depth" values were manually assigned to each data object according to the detail of the content from the perspectives of hypermedia and software engineering. Structures such as subtours and levels of detail created in the previous stage helped identify which data objects could be adaptively pruned from the tour according the the user preferences, and which data objects were essential to the structure of the tour. As with the *Introduction to Rheumatology* example,

```
tour foo
0 foo/bar
1 lod foo/baz
        0 foo/baz/a
        1 tour foo/baz/b
                0 foo/baz/x
                1 foo/baz/y
                2 foo/baz/z
        1 endtour
1 endlod
endtour
```

tour foo	start a FOHM tour structure with id *foo*. This structure represents the complete tour.
n foo/bar	bind a reference to the FOHM data object *foo/bar* at position n in the parent structure.
n lod foo/baz	bind a FOHM level of detail structure with id *foo/baz* at position n in the parent structure.
n endlod	end the level of detail structure bound at position n in the parent structure.
n tour foo/baz/b	bind a FOHM tour structure with id *foo/baz/b* at position n in the parent structure.
n endtour	end the tour structure bound at position n in the parent structure.
endtour	end the tour structure.

FIGURE 3.2: Simple notation for representing tour structure.

values for *hm_depth* (hypermedia depth) and *se_depth* (software engineering depth) were either 10 (*Basic*), 20 (*Extended*), or 50 (*Detailed*). Appendix E shows a data object with manually assigned depth values.

3.2.5 Creating glossary linkbase

The `fohmdata2fohmglossary` script (Appendix H) extracted each glossary term from the XML representation of the FOHM data objects, and generated a corresponding FOHM glossary link structure (in XML), similar to that shown in Appendix A, for the term. Short definitions for each glossary term were then manually added.

Script usage:

```
fohmdata2fohmglossary < data.xml > glossary.xml
```

Chapter 4

Discussion and Conclusion

This report recounts the experiences of understanding the operation of the HA^{3}L framework (using the *Introduction to Rheumatology* example). This understanding is then used to successfully demonstrate how *Hypermedia and the Web Online* content can be adapted and served using HA^{3}L. Figure 4 illustrates how a guided tour through the *Development Process* of the book is adapted according to user knowledge of hypermedia and software engineering. Figure 4 shows the *Hypermedia and the Web Online* example in action. The remainder of this section discusses the suitability of the HA^{3}L framework for serving an online, adaptive *Hypermedia and the Web Online* resource.

Scalability HA^{3}L currently only supports a single user interaction. However, it is estimated that changes required to extend the code to include multiple user support are minimal. A user model agent would be required for each user of the system, and other agents would have to locate the user agent specific to the current user request before updating the user model. User model agents may have to be spawned within the SOFAR framework in response to new user connections. Users may have to log in to the site to view personalised content.

Reponsiveness The responsiveness of HA^{3}L in both the *Introduction to Rheumatology* and *Hypermedia and the Web Online* examples was found to be slow. This slow response can only worsen when we consider a distributed agent platform and multiple users, but may be an feature of the SoFAR framework rather than a specific problem with the design of HA^{3}L.

Reliability During experimentation with the *Introduction to Rheumatology* example and subsequent construction of the *Hypermedia and the Web Online* example, HA^{3}L was noted to 'lock up' or crash at times, leading to loss of user model data.

Adaptive Features HA^{3}L is designed to provide adaptive (linear) tours through a topic, and as such may not scale to support adaptive navigation of a (non-linear) hypertext resource.

User Modelling HA³L's simple user modelling features, although effective in the *Introduction to Rheumatology* example, proved to be limited in serving adaptive *Hypermedia and the Web Online* content, requiring extensions as outlined in Section 3.1. There is a concern that further (non-trivial) extensions will be required to support the complex set of interactions needed for the *Hypermedia and the Web Online* resource, but these requirements need to be formalised and discussed in detail first.

FOHM Structure Construction The construction of FOHM tours using the XML representation is a particularly arduous and complicated task, and for large content bases may incur a significantly large effort. Investigation of 'intermediate representations' (such as that described in Section 3.2.3) and better tools for automatic construction are badly needed.

Despite these drawbacks, the adaptive approach that HA³L embodies certainly seems promising; indeed it is feasible that the services offered by a *Hypermedia and the Web Online* resource could include a number of themed guided tours through a network of content. The next step is to carry out a user-based evaluation of the HA³L approach to discover whether its adaptive presentation of content is useful to users of varying backgrounds.

(a)   (b)

FIGURE 4.1: Tours presented to users with extensive (a) and basic (b) hypermedia and
software engineering backgrounds
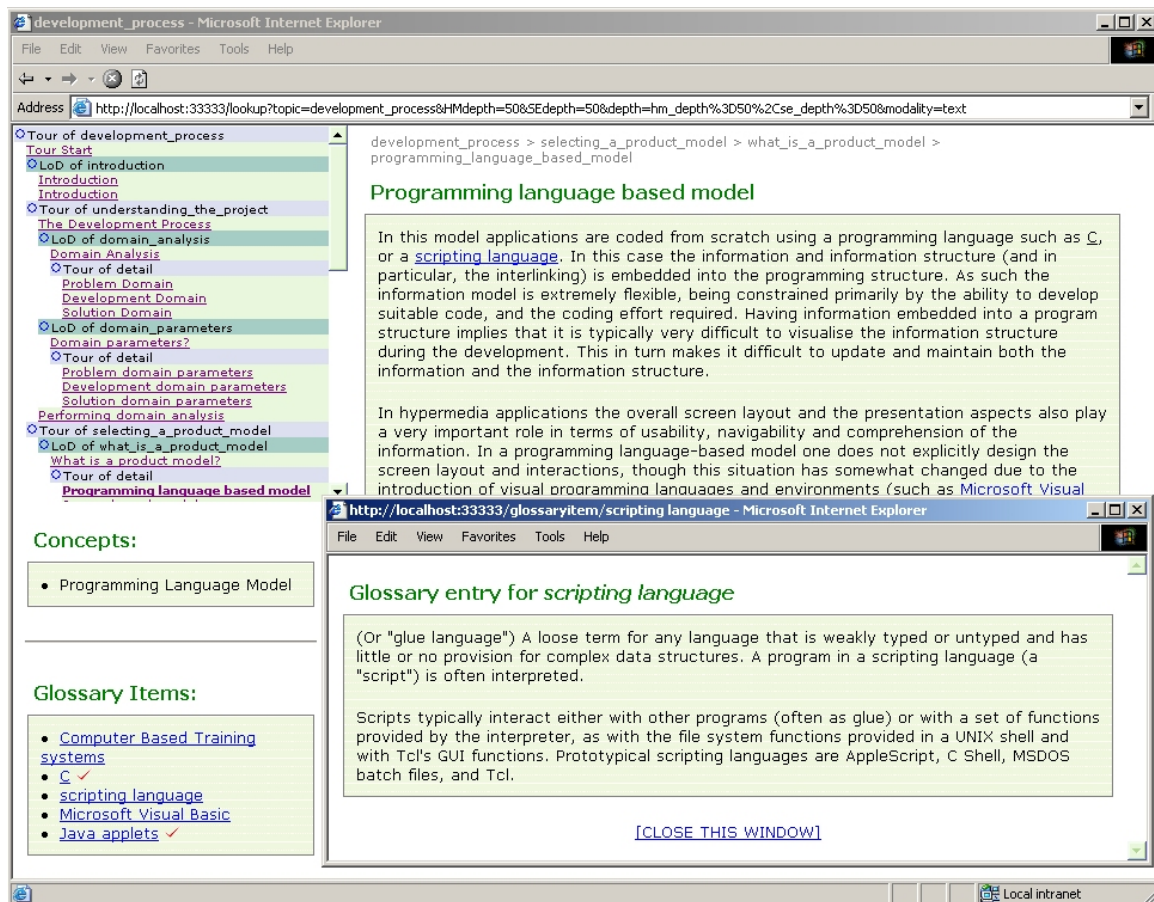
FIGURE 4.2: Following the *Development Process* tour.

Appendix A

FOHM Glossary Link Structure (*Introduction to Rheumatology* example)

```
<association id="glossary/adhesive capsulitis">
  <relationtype>glossary</relationtype>
  <description>Glossary entry for adhesive capsulitis</description>
  <structure>link</structure>
  <feature>direction</feature>
  <binding>
    <reference missing="variable">
      <locspec>
        <regioncontent>adhesive capsulitis</regioncontent>
      </locspec>
    </reference>
    <featurevalue feature="direction">source</featurevalue>
  </binding>
  <binding>
    <reference>
      <data>
        <datacontent>A synonym for frozen shoulder.</datacontent>
      </data>
    </reference>
    <featurevalue feature="direction">destination</featurevalue>
  </binding>
</association>
```

Appendix B

FOHM Data Object Structure (*Introduction to Rheumatology* example)

```xml
<data id="approach_to_patient/technique/overview">
  <behaviour>
    <event>display</event>
    <behaviourvalue key="title">Technique</behaviourvalue>
    <behaviourvalue key="concept0">technique</behaviourvalue>
    <behaviourvalue key="concept0">examination</behaviourvalue>
    <behaviourvalue key="glossary0">musculoskeletal system</behaviourvalue>
  </behaviour>
  <context>
    <contextvalue key="depth">10</contextvalue>
  </context>
  <datacontent>In order to carry out an examination of the musculoskeletal system quickly
  and efficiently and with least disturbance to the patient, it is necessary that both patient
  and examiner are relaxed and comfortable.  As with other aspects of physical examination,
  it is important not to inflict unnecessary pain or discomfort on the patient.  You must always
  be alert to the possibility that whatever you are doing may cause discomfort to the patient.
  This may be achieved partly by ensuring that, instead of focusing your attention on the part
  that you are examining, you observe the patient's facial expression during the examination.
  This will tell you whether what you are doing is acceptable or not.</datacontent>
</data>
```

Appendix C

FOHM Tour Structure (*Introduction to Rheumatology* example)

```
<association id="approach_to_patient">
  <relationtype>tour</relationtype>
  <feature>position</feature>

  <binding>
    <reference>
      <association id="approach_to_patient/technique">
        <relationtype>lod</relationtype>
        <structure>link</structure>
        <feature>position</feature>

        <binding>
          <reference>
            <data id="approach_to_patient/technique/overview" state="id"/>
          </reference>
          <featurevalue feature="position">0</featurevalue>
        </binding>

        <binding>
          <reference>
            <association id="approach_to_patient/technique/detailed">
              <relationtype>tour</relationtype>
              <structure>link</structure>
              <feature>position</feature>
              <context>
                <contextvalue key="depth">50</contextvalue>
              </context>

              <binding>
                <reference>
                  <data id="approach_to_patient/technique/detailed/feel" state="id"/>
                </reference>
                <featurevalue feature="position">0</featurevalue>
              </binding>
```

```
            <binding>
              <reference>
                <data id="approach_to_patient/technique/detailed/look" state="id"/>
              </reference>
              <featurevalue feature="position">1</featurevalue>
            </binding>

            <binding>
              <reference>
                <data id="approach_to_patient/technique/detailed/move" state="id"/>
              </reference>
              <featurevalue feature="position">2</featurevalue>
            </binding>

          </association>
        </reference>
        <featurevalue feature="position">1</featurevalue>
      </binding>

    </association>
  </reference>
  <featurevalue feature="position">0</featurevalue>
</binding>

<binding>
  <reference>
    <association id="approach_to_patient/examination">
      <relationtype>lod</relationtype>
      <structure>link</structure>
      <feature>position</feature>

      <binding>
        <reference>
          <data id="approach_to_patient/examination/overview" state="id"/>
        </reference>
        <featurevalue feature="position">0</featurevalue>
      </binding>

      <binding>
        <reference>
          <data id="approach_to_patient/examination/hand" state="id"/>
        </reference>
        <featurevalue feature="position">1</featurevalue>
      </binding>

      <binding>
        <reference>
          <association id="approach_to_patient/examination/ankle">
            <relationtype>concept</relationtype>
            <structure>link</structure>
            <feature>media</feature>
            <context>
              <contextvalue key="depth">20</contextvalue>
            </context>

            <binding>
              <reference>
                <data id="approach_to_patient/examination/ankle/text" state="id"/>
```

```
                </reference>
                <featurevalue feature="media">text</featurevalue>
              </binding>

              <binding>
                <reference>
                  <data id="approach_to_patient/examination/ankle/video" state="id"/>
                </reference>
                <featurevalue feature="media">video</featurevalue>
              </binding>


            </association>
          </reference>
          <featurevalue feature="position">2</featurevalue>
        </binding>


      </association>
    </reference>
    <featurevalue feature="position">1</featurevalue>
  </binding>

</association>
```

Appendix D

FOHM Data Object skeleton generated from *Development Process* Chapter

```
<data id="development_process/selecting_a_product_model/what_is_a_product_model/information_centered_model">
        <behaviour>
                <event>display</event>
                <behaviourvalue key="title">Information centred model</behaviourvalue>
                <behaviourvalue key="glossary0"></behaviourvalue>
                <behaviourvalue key="concept0"></behaviourvalue>
        </behaviour>
        <context>
                <contextvalue key="hm_depth"></contextvalue>
                <contextvalue key="se_depth"></contextvalue>
        </context>
        <datacontent><![CDATA[
                <P>In this model the information and its structure...
        ]]></datacontent>

</data>
```

Appendix E

FOHM Data Object after manual editing

```
<data id="development_process/selecting_a_product_model/what_is_a_product_model/information_centered_model">
        <behaviour>
                <event>display</event>
                <behaviourvalue key="title">Information centred model</behaviourvalue>
                <behaviourvalue key="glossary0">Hypertext Markup Language</behaviourvalue>
                <behaviourvalue key="glossary1">SGML</behaviourvalue>
                <behaviourvalue key="glossary2">Multimedia Viewer</behaviourvalue>
                <behaviourvalue key="concept0">Information Model</behaviourvalue>
        </behaviour>
        <context>
                <contextvalue key="hm_depth">10</contextvalue>
                <contextvalue key="se_depth">50</contextvalue>
        </context>
        <datacontent><![CDATA[
                <P>In this model the information and its structure...
        ]]></datacontent>

</data>
```

Appendix F

`html2fohmdata` listing

```
while (<STDIN>) {

        if (/<H3>(<A NAME='.*?'><\/A>)?(.*?)<\/H3>/i) {
                $h3 = $2;
                next;
        }
        if (/<H4>(<A NAME='.*?'><\/A>)?(.*?)<\/H4>/i) {
                doContent($id,$title); # data object for previous section
                $h4 = $2;
                $id = "$h3/$h4";
                $title = $h4;
                next;
        }
        if (/<H5>(<A NAME='.*?'><\/A>)?(.*?)<\/H5>/i) {
                doContent($id,$title); # data object for previous section
                $h5 = $2;
                $id = "$h3/$h4/$h5";
                $title = $h5;
                next;
        }
        if (/<H6>(<A NAME='.*?'><\/A>)?(.*?)<\/H6>/i) {
                doContent($id,$title); # data object for previous section
                $id = "$h3/$h4/$h5/$1";
                $title = $1;
                next;
        }

        $datacontent .= $_;
}
doContent($id,$title);

sub doContent {
        my ($id,$title) = @_;
        next if $datacontent eq "";
        $id =~ s/ /_/g;
        $id = lc($id);
        print <<END;
<data id="development_process/$id">
        <behaviour>
                <event>display</event>
```

```
                <behaviourvalue key="title">$title</behaviourvalue>
                <behaviourvalue key="glossary0"></behaviourvalue>
                <behaviourvalue key="concept0"></behaviourvalue>
        </behaviour>
        <context>
                <contextvalue key="hm_depth">10</contextvalue>
                <contextvalue key="se_depth">10</contextvalue>
        </context>
        <datacontent>
                $datacontent
        </datacontent>
</data>

END
        $datacontent = "";
}
```

Appendix G

`tour2fohmstruct` listing

```
print "<linkbase>\n";
while (<STDIN>) {
        chomp;
        if (/^(\t*)tour (.*?)$/) { # start of main tour
                print<<END;
$1<association id="$2">
$1      <relationtype>tour</relationtype>
$1      <structure>link</structure>
$1      <feature>position</feature>
END
                next;
        }
        if (/^(\t*)endtour$/) { # end of main tour
                print<<END;
$1</association>
END
                next;
        }
        if (/^(\t*)[0-9]+ lod (.*?)$/) { # start of lod
                print<<END;
$1<binding>
$1      <reference>
$1              <association id="$2">
$1              <relationtype>lod</relationtype>
$1              <structure>link</structure>
$1              <feature>position</feature>
END
                next;
        }
        if (/^(\t*)([0-9]+) endlod$/) { # end of lod
                print<<END;
$1              </association>
$1      </reference>
$1      <featurevalue feature="position">$2</featurevalue>
$1</binding>
END
                next;
        }
        if (/^(\t*)[0-9]+ tour (.*?) \[(.*?)\]$/) { # start of subtour (with context)
                print<<END;
```

```
$1<binding>
$1      <reference>
$1              <association id="$2">
$1                      <relationtype>tour</relationtype>
$1                      <structure>link</structure>
$1                      <feature>position</feature>
$1                      <context>
END
              foreach $context (split(',',$3)) {
                      @c = split '=', $context;
                      if (scalar(@c) == 2) {
                              print<<END;
$1                              <contextvalue key="$c[0]">$c[1]</contextvalue>
END
                      }
              }
              print <<END;
$1                      </context>
END
              next;
      }
      if (/^(\t*)[0-9]+ tour (.*?)$/) { # start of subtour
              print<<END;
$1<binding>
$1      <reference>
$1              <association id="$2">
$1                      <relationtype>tour</relationtype>
$1                      <structure>link</structure>
$1                      <feature>position</feature>
END
              next;
      }
      if (/^(\t*)([0-9]+) endtour$/) { # end of subtour
              print<<END;
$1              </association>
$1      </reference>
$1      <featurevalue feature="position">$2</featurevalue>
$1</binding>
END
              next;
      }
      if (/^(\t*)([0-9]+) (.*?)$/) { # data reference
              print<<END;
$1<binding>
$1      <reference>
$1              <data id="$3" state="id"/>
$1      </reference>
$1      <featurevalue feature="position">$2</featurevalue>
$1</binding>
END
              next;
      }
}
print "</linkbase>\n";
```

Appendix H

`fohmdata2fohmglossary` listing

```
while (<>) {
        if (/<behaviourvalue key="glossary[0-9]+">(.*?)<\/behaviourvalue>/i) {
                $glossary_items{$1}++;
        }
}

print "<linkbase>\n";

foreach $term (keys %glossary_items) {
        print <<END;
<association id="glossary/$term">
        <relationtype>glossary</relationtype>
        <structure>link</structure>
        <feature>direction</feature>
        <binding>
                <reference missing="variable">
                        <locspec>
                                <regioncontent>$term</regioncontent>
                        </locspec>
                </reference>
                <featurevalue feature="direction">source</featurevalue>
        </binding>
        <binding>
                <reference>
                        <data>
                                <datacontent><![CDATA[Definition of $term.]]></datacontent>
                        </data>
                </reference>
                <featurevalue feature="direction">destination</featurevalue>
        </binding>
</association>

END
}
print "</linkbase>\n";
```

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