Experience Report: Serving Hypermedia and the Web Online with HA$^3$L

by

Timothy Miles-Board

Technical Report ECSTR-IAM03-003

Faculty of Engineering and Applied Science
Department of Electronics and Computer Science
Intelligence, Agents, Multimedia Group

July 15, 2003
## Contents

1 Introduction

2 Exploring HA³L and the *Introduction to Rheumatology* Example
   2.1 User Model Agent ................................................. 3
      2.1.1 Contract Summary ........................................... 4
   2.2 Linky Agent .......................................................... 5
      2.2.1 Contract Summary ............................................. 5
   2.3 User Agent ............................................................ 5
      2.3.1 Lookup ........................................................... 7
      2.3.2 Table of Contents ............................................. 8
      2.3.3 Main Content ................................................ 8
      2.3.4 Infobar ......................................................... 10
      2.3.5 Glossary Page ............................................... 11
      2.3.6 Letting the User Agent Choose a Tour ...................... 12
   2.4 FOHM Structures .................................................. 13
      2.4.1 Glossary Links ................................................. 13
      2.4.2 Guided Tours ................................................ 13

3 Serving *Hypermedia and the Web Online* with HA³L
   3.1 Tailoring representation of User Knowledge Level ............ 17
   3.2 Building FOHM Structures ......................................... 18
      3.2.1 Converting HTML pages to skeleton FOHM data objects ...... 19
      3.2.2 Editing skeleton data objects ................................ 20
      3.2.3 Creating tour structure ..................................... 20
      3.2.4 Assigning depth values ...................................... 20
      3.2.5 Creating glossary linkbase .................................. 21

4 Discussion and Conclusion ............................................ 23

A FOHM Glossary Link Structure (*Introduction to Rheumatology* example) 27

B FOHM Data Object Structure (*Introduction to Rheumatology* example) 29

C FOHM Tour Structure (*Introduction to Rheumatology* example) 31

D FOHM Data Object skeleton generated from *Development Process* Chapter 35
E  FOHM Data Object after manual editing  37
F  html2fohmdata listing  39
G  tour2fohmstruct listing  41
H  fohmdata2fohmglossary listing  43
Bibliography  45
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Choosing a tour and setting user preferences.</td>
<td>2</td>
</tr>
<tr>
<td>2.1</td>
<td>Basic HA³L architecture.</td>
<td>4</td>
</tr>
<tr>
<td>2.2</td>
<td>Example queries handled by the Linky Agent.</td>
<td>6</td>
</tr>
<tr>
<td>2.3</td>
<td>Pruning a FOHM association using context constraints.</td>
<td>6</td>
</tr>
<tr>
<td>2.4</td>
<td>Page layout generated by lookup request.</td>
<td>8</td>
</tr>
<tr>
<td>2.5</td>
<td>Start screen for simple tour with detail of table of contents for extended</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>and detailed tours.</td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>Main content shown with user length preference set.</td>
<td>10</td>
</tr>
<tr>
<td>2.7</td>
<td>Main content presented according to user modality preference.</td>
<td>10</td>
</tr>
<tr>
<td>2.8</td>
<td>Concepts and glossary links presented by the Infobar.</td>
<td>11</td>
</tr>
<tr>
<td>2.9</td>
<td>Glossary definition.</td>
<td>12</td>
</tr>
<tr>
<td>2.10</td>
<td>FOHM glossary link structure.</td>
<td>13</td>
</tr>
<tr>
<td>2.11</td>
<td>FOHM tour structure.</td>
<td>15</td>
</tr>
<tr>
<td>3.1</td>
<td>Choosing a <em>Hypermedia and the Web</em> tour and indicating current knowledge.</td>
<td>18</td>
</tr>
<tr>
<td>3.2</td>
<td>Simple notation for representing tour structure.</td>
<td>21</td>
</tr>
<tr>
<td>4.1</td>
<td>Tours presented to users with differing backgrounds.</td>
<td>25</td>
</tr>
<tr>
<td>4.2</td>
<td>Following the <em>Development Process</em> tour.</td>
<td>26</td>
</tr>
</tbody>
</table>
Chapter 1

Introduction

HA³L (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). HA³L 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. HA³L 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 HA³L, 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 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 HA³L framework (using the Introduction to Rheumatology example as

\(^1\)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 intermediary 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).
Chapter 2 Exploring HA³L and the Introduction to Rheumatology Example

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 \((\text{visited}, \text{dataobject.id})\), 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 \((\text{glossary}, \text{glossary.id})\), 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 \((\text{concept,})\) (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 relationshipsType 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 relationshipsType 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
Chapter 2 Exploring HA$^3$L and the Introduction to Rheumatology Example

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

(a)

(b)

(c)

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.
2.3.2 Table of Contents


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 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](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.
Chapter 2 Exploring HA³L and the Introduction to Rheumatology Example

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
Chapter 2 Exploring HA³L and the Introduction to Rheumatology Example

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

\(^1\)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).
Chapter 2 Exploring HA$^3$L and the Introduction to Rheumatology Example

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 preference) 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.
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 HA$^3$L interactions.

The user agent queries each agent in the framework able to undertake the contract $\text{Query}\_\text{Ref}(\text{UserInfo})$ 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 $\text{Query}\_\text{Ref}(\text{Query})$, 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.
The user agent also informs any agents able to undertake the contract $\text{Inform}(\text{UserInfo})$ 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` — describes 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$^2$:

$^2$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 $\leq 10$), 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

\(^1\)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.
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 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 to 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

<table>
<thead>
<tr>
<th>tour foo</th>
<th>start a FOHM tour structure with id foo. This structure represents the complete tour.</th>
</tr>
</thead>
<tbody>
<tr>
<td>n foo/bar</td>
<td>bind a reference to the FOHM data object foo/bar at position n in the parent structure.</td>
</tr>
<tr>
<td>n lod foo/baz</td>
<td>bind a FOHM level of detail structure with id foo/baz at position n in the parent structure.</td>
</tr>
<tr>
<td>n endlod</td>
<td>end the level of detail structure bound at position n in the parent structure.</td>
</tr>
<tr>
<td>n tour foo/baz/b</td>
<td>bind a FOHM tour structure with id foo/baz/b at position n in the parent structure.</td>
</tr>
<tr>
<td>n endtour</td>
<td>end the tour structure bound at position n in the parent structure.</td>
</tr>
</tbody>
</table>
endtour

Figure 3.2: Simple notation for representing tour structure.

values for $hm_{\text{depth}}$ (hypermedia depth) and $se_{\text{depth}}$ (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 HA³L 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 HA³L. 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 HA³L framework for serving an online, adaptive Hypermedia and the Web Online resource.

**Scalability** HA³L 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.

**Responsiveness** The responsiveness of HA³L 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 HA³L.

**Reliability** During experimentation with the Introduction to Rheumatology example and subsequent construction of the Hypermedia and the Web Online example, HA³L was noted to ‘lock up’ or crash at times, leading to loss of user model data.

**Adaptive Features** HA³L 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. HA$^3$L’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 HA$^3$L 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 HA$^3$L approach to discover whether its adaptive presentation of content is useful to users of varying backgrounds.
Chapter 4 Discussion and Conclusion

Figure 4.1: Tours presented to users with extensive (a) and basic (b) hypermedia and software engineering backgrounds

<table>
<thead>
<tr>
<th>Tour of development process</th>
<th>Tour Start</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tour of introduction</td>
<td>Introduction</td>
</tr>
<tr>
<td>Tour of understanding the project</td>
<td>Introduction</td>
</tr>
<tr>
<td>The Development Process</td>
<td></td>
</tr>
<tr>
<td>Tour of domain analysis</td>
<td>Domain Analysis</td>
</tr>
<tr>
<td>LoD of domain parameters</td>
<td>Domain parameters</td>
</tr>
<tr>
<td>Tour of detail</td>
<td></td>
</tr>
<tr>
<td>Problem domain parameters</td>
<td></td>
</tr>
<tr>
<td>Development domain parameters</td>
<td></td>
</tr>
<tr>
<td>Solution domain parameters</td>
<td></td>
</tr>
<tr>
<td>Performing domain analysis</td>
<td></td>
</tr>
<tr>
<td>Tour of selecting a product model</td>
<td></td>
</tr>
<tr>
<td>LoD of what is a product model</td>
<td></td>
</tr>
<tr>
<td>What is a product model</td>
<td></td>
</tr>
<tr>
<td>Tour of detail</td>
<td></td>
</tr>
<tr>
<td>What is a process model</td>
<td></td>
</tr>
<tr>
<td>Tour of selecting a process model</td>
<td></td>
</tr>
<tr>
<td>LoD of what is a process model</td>
<td></td>
</tr>
<tr>
<td>What is a process model</td>
<td></td>
</tr>
<tr>
<td>Tour of factors influencing the process</td>
<td></td>
</tr>
<tr>
<td>Factors influencing the process</td>
<td></td>
</tr>
<tr>
<td>LoD of waterfall model of development</td>
<td></td>
</tr>
<tr>
<td>Waterfall model of development</td>
<td></td>
</tr>
<tr>
<td>Tour of project planning and management</td>
<td></td>
</tr>
<tr>
<td>LoD of project planning</td>
<td>Project Planning</td>
</tr>
<tr>
<td>Project planning</td>
<td></td>
</tr>
<tr>
<td>Project management</td>
<td></td>
</tr>
<tr>
<td>LoD of work breakdown and scheduling</td>
<td></td>
</tr>
<tr>
<td>Work breakdown and scheduling</td>
<td></td>
</tr>
<tr>
<td>Tour of risk management</td>
<td>Risk Management</td>
</tr>
<tr>
<td>Quality Assurance</td>
<td></td>
</tr>
<tr>
<td>Tour of framework for documentation</td>
<td></td>
</tr>
<tr>
<td>Framework for Documentation</td>
<td></td>
</tr>
</tbody>
</table>

(a) (b)
Chapter 4 Discussion and Conclusion

Figure 4.2: Following the Development Process tour.

Programming language based model

In this model applications are coded from scratch using a programming language such as C, or a scripting language. In this case the information and information structure (and in particular, the interlinking) is embedded into the programming structure. As such the information model is extremely flexible, being constrained primarily by the ability to develop suitable code, and the coding effort required. Having information embedded into a program structure implies that it is typically very difficult to visualise the information structure during the development. This in turn makes it difficult to update and maintain both the information and the information structure.

In hypermedia applications the overall screen layout and the presentation aspects also play a very important role in terms of usability, navigability and comprehension of the information. In a programming language-based model one does not explicitly design the screen layout and interactions, though this situation has somewhat changed due to the introduction of visual programming languages and environments (such as Microsoft Visual

Glossary entry for scripting language

(Or "glue language") A loose term for any language that is weakly typed or untyped and has little or no provision for complex data structures. A program in a scripting language (a "script") is often interpreted.

Scripts typically interact either with other programs (often as glue) or with a set of functions provided by the interpreter, as with the file system functions provided in a UNIX shell and with Tcl's math functions. Prototypical scripting languages are AppleScript, C Shell, MS-DOS batch files, and Tcl.
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)

<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>
</association>

<binding>
  <reference>
    <association id="approach_to_patient/technique">
      <relationtype>lod</relationtype>
      <structure>link</structure>
      <feature>position</feature>
    </association>
  </reference>
  <featurevalue feature="position">0</featurevalue>
</binding>

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

31
Appendix C FOHM Tour Structure (Introduction to Rheumatology example)

```xml
  <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>
    </association>
    <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>
      </association>
      <reference>
        <data id="approach_to_patient/examination/ankle/text" state="id"/>
      </reference>
    </reference>
  </binding>
```
Appendix C FOHM Tour Structure (Introduction to Rheumatology example)

</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="glossary"></behaviourvalue>
    <behaviourvalue key="concept"></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...</p>]]></datacontent>
</data>
Appendix F

html2fohmdata listing

```perl
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
        $h6 = $2;
        $id = "$h3/$h4/$h5/$h6";
        $title = "$h6";
        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/$id"
    <behaviour>
        <event>display</event>
END;
```
<behaviourvalue key="title">$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

```perl
print "<linkbase\n";
while (<STDIN>) {
    chomp;
    if (/^\t*\tour\ (.*)$/i) { # start of main tour
        print<<END;
$1<association id="$2">
$1 <relationtype>tour</relationtype>
$1 <structure>link</structure>
$1 <feature>position</feature>
END
        next;
    }
    if (/^\t*endtour$/i) { # end of main tour
        print<<END;
$1</association>
END
        next;
    }
    if (/^\t*\[0-9]+ lod (.*?)$/i) { # 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$/i) { # end of lod
        print<<END;
$1 </association>
$1 </reference>
$1 <featurevalue feature="position">$2</featurevalue>
$1</binding>
END
        next;
    }
    if (/^\t*\[0-9]+ tour (.*) \[(.*)\]/i) { # start of subtour (with context)
        print<<END;
41
```

$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 "</context>
END

if (/^\s*(\[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>
$1   next;
END
}
if (/^\s*(\[0-9]+) endtour$/ ) { # end of subtour
  print<<END;
$1  </association>
$1  </reference>
$1  <featurevalue feature="position">$2</featurevalue>
$1 </binding>
END
}
if (/^\s*(\[0-9]+) (.*?)$/ ) { # data reference
  print<<END;
$1  <binding>
$1  <reference>
$1   <data id="$3" state="id"/>
$1   <featurevalue feature="position">$2</featurevalue>
$1 </binding>
END
  }
}

print "</linkbase>\n";}
Appendix H

fohmdat2fohmglossary listing

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

print "<linkbase>
";

foreach $term (keys %glossary_items) {
    print "</linkbase>\n";
    print <<END;
    <association id="glossary/$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>
                    <![CDATA[Definition of $term.]]></datacontent>
                </data>
            </reference>
            <featurevalue feature="direction">destination</featurevalue>
        </binding>
    </association>
END
}
print "</linkbase>\n";
Bibliography


