

Hypertext representation for education and learning

Cristòfol Rovira Fontanals

Universitat Pompeu Fabra

cristofol.rovira@cpis.upf.se

Abstract

MAIDHEA is a representational method for using hypertext for educational purposes. MAIDHEA uses OMT (object-oriented modelling technique) class diagram notation for modelling navigation structures, navigation systems and instructional design.

Keywords

Hypertext, distance learning, navigation design, web site design, object orientation, information systems modelling, information representation, hypertext representation, instructional design, object diagram, hypertext design.

1. Introduction

MAIDHEA (Spanish acronym for interdisciplinary abstract modelling of hypertext for education and learning) is a method for graphically representing hypertext for educational and learning purposes. MAIDHEA is a result of experience over five years in developing instruction materials for the Online Master in Digital Documentation <<http://www.documentaciondigital.org>>, a process which has involved the following disciplines in the process of hypertext design:

- * Educational science in the processes of instructional design and theories of content organisation, in particular Elaboration Theory (Reigeluth, 1983, 1999).
- * Documentation Sciences in the methods and models for structure design and hypertext navigation systems.
- * Hypertext theory for education and learning with the Cognitive Flexibility Theory (Spiro et al. 1990; Spiro and Chang Jehng, 1991).
- * Software engineering and methods for representing object oriented information systems.

2. *MAIDHEA*

The objectives of representation using MAIDHEA are:

- * To represent hypertext instruction materials and hypertext in general using diagrams to facilitate communication between people in interdisciplinary teams who are participating in development work and subsequent maintenance.
- * Integrated representation using the same notation of instructional design, content organisation and sequencing, navigation systems design and the structuring of hypertext information.
- * To represent generic models of hypertext that can be applied as templates for creating new hypertext instruction materials.

The basic formulation of MAIDHEA modelling comes from object orientation. Hypertext instruction materials and hypertext in general are therefore considered to be information systems organised into collections of objects, which have structures of data with attributes and properties.

MAIDHEA also comprises the majority of elements that are explicitly and implicitly found in traditional methodological proposals for hypertext design and modelling, such as HAM (Campbell, 1988), HDM (Garzotto, 1990), Lange (1994), RMM (Isakowitz, 1995) and OOHDM (Schwabe, 1996). These elements are:

- * Definition of different perspectives for observing and then representing hypertext.
- * Graphic representation of the different perspectives to form different interconnected models of hypertext.
- * Clear separation between design and implementation stages in the process of creating hypertext.
- * The establishment of element types and instances within the context of the paradigm of the object orientation of software engineering.

The choice of OMT (Object Modelling Technique) class diagram notation for use in MAIDHEA is due to ease of use. Other representation systems for object orientation analysis, such as OML (Open Modelling Language) or UML(Unified Modelling Language), can also be used and are just as effective.

The primordial principle for applying object oriented modelling to the design of hypertext instructional materials is to consider that each node or page of a hypertext document is an instance of an object with its attributes or characteristics and that this page instance belongs to a generic class of pages.

They are also group objects in different pages and page fragments that are an entity unto themselves and form part of many pages. Classes in MAIDHEA can therefore be classified according to three types:

- * Classes that represent page types
- * Classes that represent types of page groups: instruction units, modules and the course itself

* Classes that represent types of page fragments, such as paragraphs or navigation elements such as fold-down menus, the graphic menu at page top, conceptual mapping, etc.

Class attributes or characteristics enable all significant data for instructional design, navigation design and even graphic design to be stored in an orderly way. Class attributes in MAIDHEA can be classified according to four types:

- * Characteristics for identifying the class: title, identifier, date when created, etc.
- * Characteristics of instructional design: instruction objectives, learning activities, duration, etc.
- * Navigation design characteristics: parent and child in the general hierarchical summary, summary options, start-up page identifier, hierarchical level of the page, etc.
- * Graphic design characteristics: colour, graphic frames at page bottom, the distribution of elements, etc.

The object oriented aggregate relationship permits the representation of the relationships between the whole and its parts amongst the objects of the hypertext instruction materials while the generalised listing allows for representation of parent-child type relationships between an object and the more refined versions of this same object that inherit the attributes of the parent class.

In keeping with the OMT, abstract classes do not have instances and they permit the representation of generalised listings between entities with common characteristics.

As can be seen from table 1, only part of the elements that make up the object oriented modelling are used. Diagrams representing hypertext documents do not include the software for hypertext functionality and only show the external design centred on information fragmentation, structuring and organisation in the hypertext instruction material. The object oriented elements related directly with the representation of this functionality, such as methods, are thus not used in MAIDHEA.

The symbols used to represent MAIDHEA modellingⁱ are standard according to OMT, with the sole addition of the directional hypertext link as just another type of relationship between object classes and object instances.

Table 1. Object oriented modelling applied to hypertext instruction materials

	Object oriented modelling for a computer programme	Object oriented modelling for a hypertext document	Object oriented modelling for hypertext instruction material
Models	Object model	Object model	Object model
	Dynamic model	-	-
	Functional model	-	-
Basic concepts	Object and instance	Node	Node set, node and node fragment
	Class	Node type	Type of node set, node and node fragment
	Attribute	Node characteristic	Characteristic of the node set, node and node fragment

	Aggregation	Node aggregation	Aggregation of the node set, node and node fragment
	Link	Hypertext link	Hypertext link
	Association	Type of link	Type of link
	Method	-	-
	Class inheritance	Node type inheritance	Inheritance of the types of node set, node and node fragment
	Polymorphism	-	-

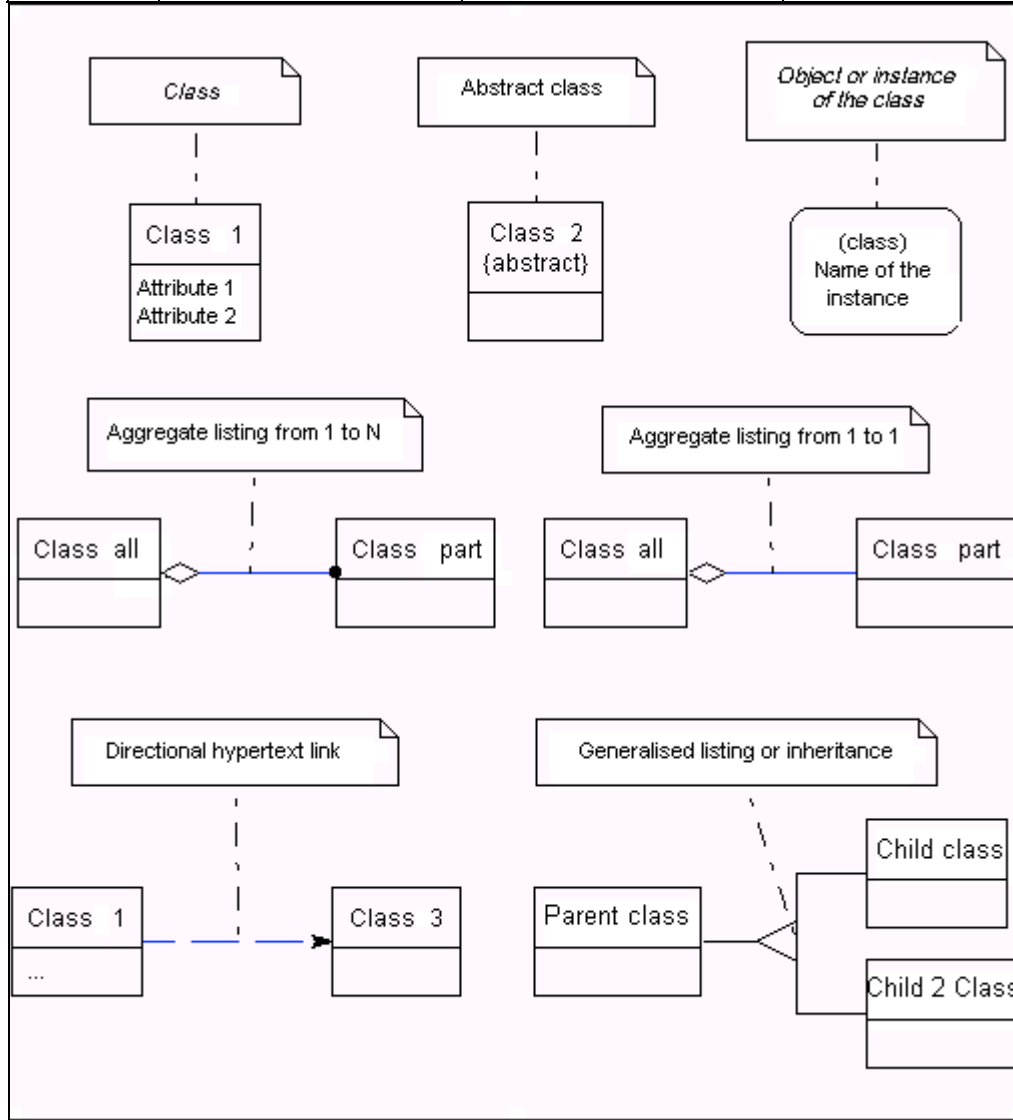


Illustration 1. Application of OMT symbols to represent hypertext instruction materials.

3. Representation of hypertext instruction materials for the Online Master in Digital Documentation

3.1. Online Master in Digital Documentation

The Online Master in Digital Documentation is co-ordinated by the Institute of Continuing Education of the Universitat Pompeu Fabra. Study is by way of distance learning and the Internet with instruction materials in hypertext format, together with the use of web technology.

The digital classroom for this Master consists of instruction materials together with other pages that contain complementary services, such as forums, chats, academic information, etc. The general structure of the course and the digital classroom is made up of six modules with four instruction units in each module. Each unit is assigned one week of study with a tutor who answers queries and chairs discussion forums.

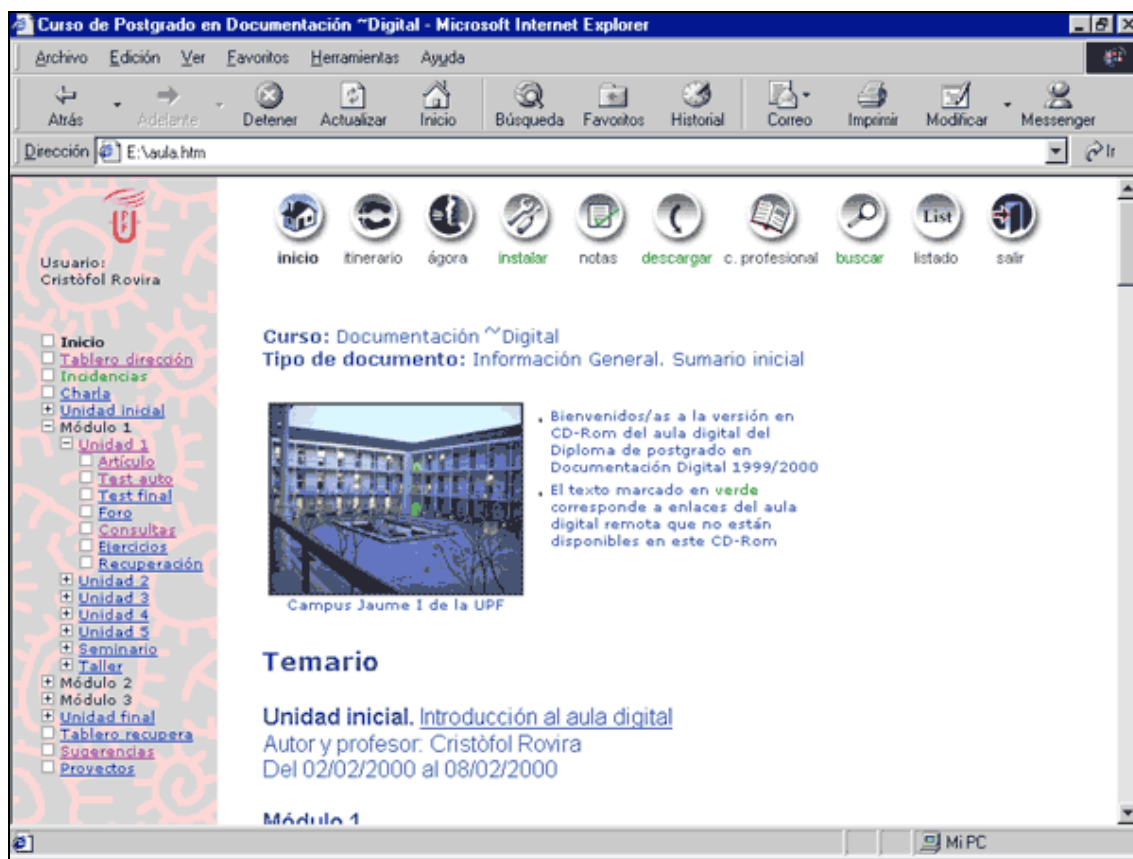


Illustration 2. Start-up page of the digital classroom for the Online Master course in Digital Documentation. On the left-hand side there is the fold-out menu with the general structure of the classroom and the course.

The generic outline of a unit is as follows:

- * A presentation page for the unit, with information on instruction objectives, duration and assessment requirements.
- * Two extensive pages with an article in academic format (abstract, introduction, development, conclusions and bibliography) containing the content of the unit. Access to the second parts of the articles is by way of a self-assessment test.
- * Various pages linked to the core article with complementary contents.
- * A page with a multiple selection self-assessment test for gaining access to the second part of the article.
- * A page with a multiple selection assessment test to be sent to the tutor.
- * A page with a discussion forum.
- * A page for doubts and queries to be sent to the tutor and for consulting his/her replies.
- * A page with an exercise to be answered in groups of two people.
- * A page with retrieval instructions with a presentation of assessment activities to be done outside of standard deadlines.

The digital classroom is supplemented with the following general pages with information, services and notice-boards concerning the overall course and are thus not assigned to any module or unit.

General information:

- * Help page
- * Page with a list of course participants
- * Page with examination marks

Overall services:

- * Page with the browser
- * Page with options for installing the digital classroom in the hard-disk of course participants
- * Page with information on the different curriculum itineraries

Notice-boards:

- * Address notice-board
- * Incidents notice-board
- * Informal chat
- * Projects notice-board
- * Retrieval notice-board
- * Suggestions notice-board

All pages in the digital classroom are connected by way of hypertext links and comprise three information structures:

- * Hierarchical structure
- * Sequential structure
- * Network structure

The hierarchical structure enables hypertext navigation in two ranges:

- * General range between all instruction unit pages.
- * Restricted range between the notice-board summary page and messages.

The sequential structure is basically implemented in the core article of each instruction unit and the lists of exam marks of the participants in the Master course. The network structure provides access by following semantic connections to any page in the digital classroom, especially between the article and its complementary pages.

3.2. Applying MAIDHEA

In the following sections, MAIDHEA modelling is used to represent hypertext instruction materials used in the Online Master in Digital Documentation and a model of the course is constructed. The following basic characteristics stand out:

a. The organisation of the instruction material content is made up of a core article with the basic contents structured in sequential form, together with a set of short complementary pages linked to the article to form a network structure. This structure is based on the implications of Cognitive Flexibility Theory (Spiro et. al. 1990; Spiro, 1991).

b. Navigation design consists of upper, lower and fold-out summaries, which show more academic structural relations (course, module, unit, exercises, etc.) and the conceptual navigation map that shows the conceptual structure of the contents according to the Theory of Elaboration (Reigeluth, 1983, 1999).

c. The implicit characteristics of the instructional design stem from the expository - communicative – transactive instructional model applied in the course, with participation strategies for large group discussions, discussions in pairs, individual projects and self-assessment questionnaires.

Application of MAIDHEA results in a generic hypertext model that can be applied when preparing hypertext instructional postgraduate materials for other subjects, especially those connected with information technologies.

3.2.1 *Web pages and navigation systems are objects*

In using MAIDHEA modelling, each Web page is an object made up ofⁱⁱ:

- * A fold-out summary (fragment-type object)
- * A graphic summary and a text summary
- * A hierarchical branch
- * Different paragraphs of various types

The eight types of paragraph used in the course with their characteristics of identification, graphic design and navigation design can be represented by way of the generalised listing:

- * Graph
- * Intervention
- * Text
- * Link
- * Title
- * Question
- * Summary
- * Participation in discussions in pairs

The generalised listing also enables different page types in the course to be represented. According to their characteristics and functions, pages can beⁱⁱⁱ:

- * Conceptual navigation map
- * Core content (article)
- * Complementary content
- * Query communication space
- * Discussion communication space
- * Information on the digital classroom
- * Academic information
- * Abstract
- * Services (browser, chat)
- * Discussion in pairs exercise
- * Multiple selection test

After the representation of page and page fragment classes, the following chapter represents page sets for making up an instructional unit, a module and the whole course in Digital

Documentation, which includes the instructional design elements in the form of the attributes and characteristics of these page sets.

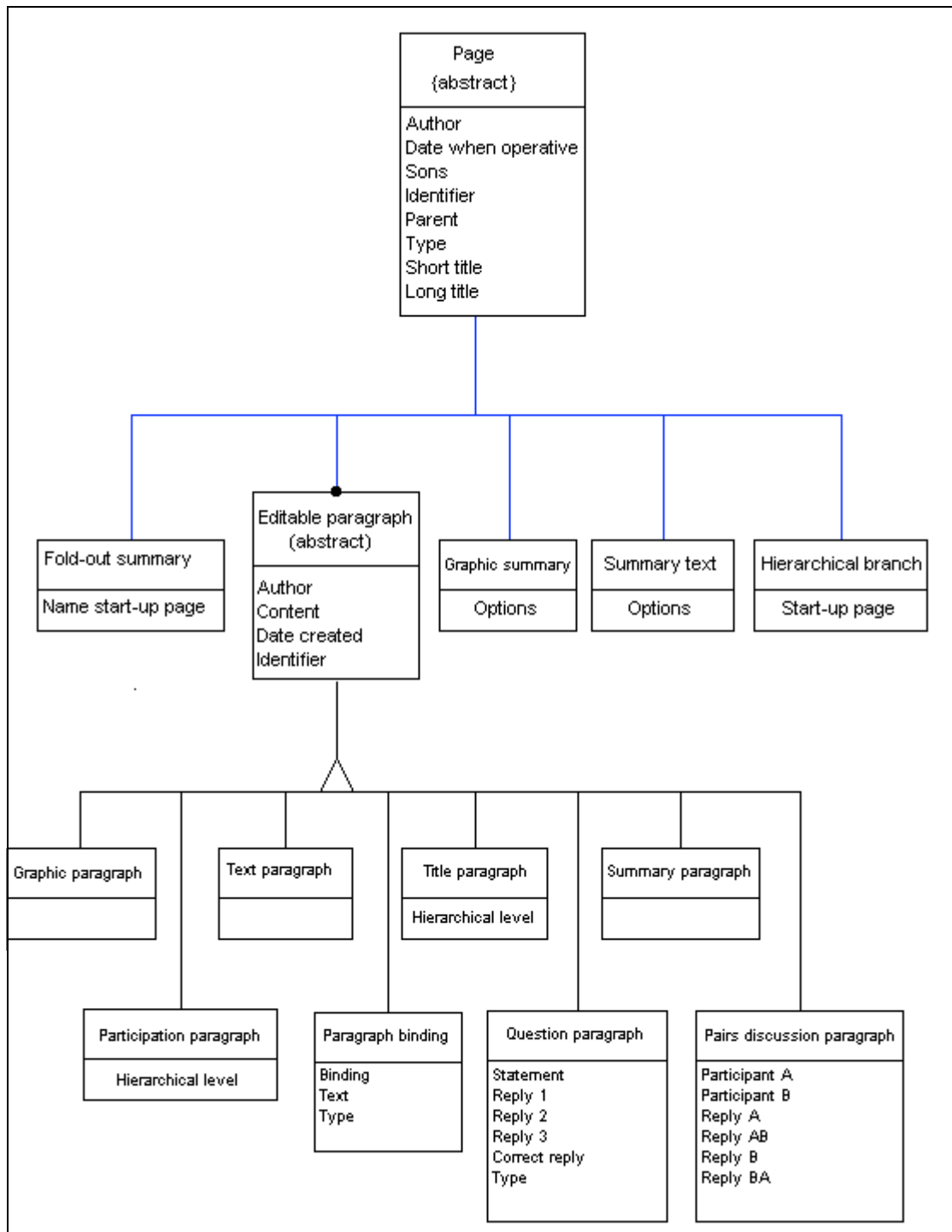


Illustration 3. Diagram of the component parts of the class page where paragraph type is shown^{iv}.

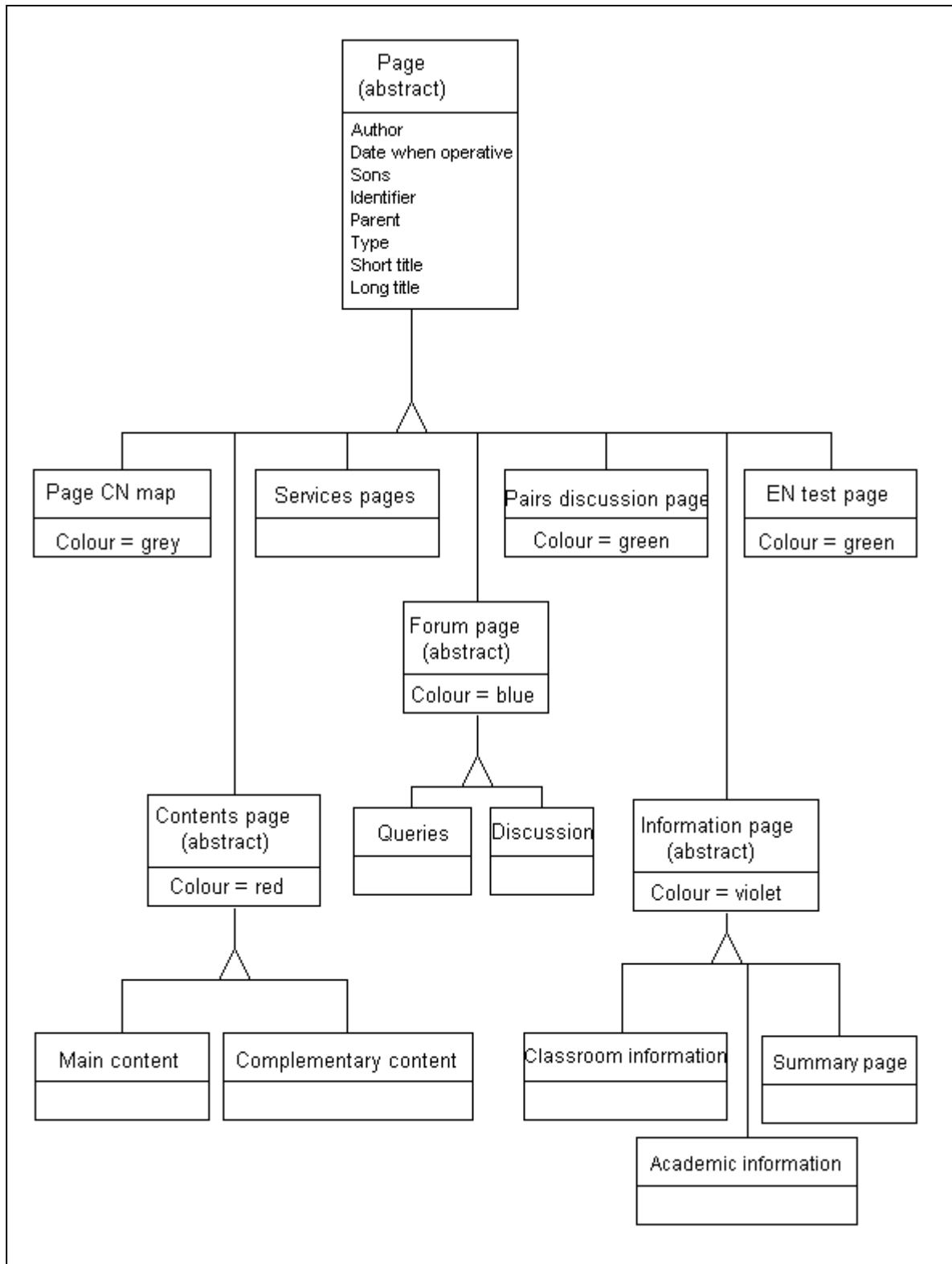


Illustration 4. The "page" class

3.2.2 Instructional design representation

In MAIDHEA modelling, use of the paradigm of object orientation is proposed for representing the following elements of instructional design that are implicit in any kind of instructional material:

- * The instructional objectives
- * The contents and how they are organised
- * Learning activities
- * Duration
- * Assessment

In order to integrate instructional design representation with hypertext representation, object orientation modelling needs to be applied in the following way:

- * A course is an abstract class of objects made up of other abstract classes (modules) and various objects from the page class.
- * A module is an abstract class of objects made up of other abstract classes (instructional units) and various objects from the page class.
- * An instructional unit is an abstract class of objects made up of various objects from the page class.

Some of the important instructional design data are considered to be attributes or properties of the course, module and instructional unit classes, for example:

- * The instructional objectives, contents, duration and assessment are attributes of the course, module and instructional unit classes, where each class has different levels of specificity, from the more generic course ones to the more specific unit ones.
- * The learning activities are attributes of the instructional unit.

By applying these principles, the Online Master in Digital Documentation can be modelled and the course class^v shown to consist of:

- * Various modules.
- * Various pages with academic information with data connected with the course.
- * One page of the class summary with a general summary of the instructional modules and units in the course.
- * Various pages on the class conceptual navigation map (the first map and the end of the course).
- * Various pages on the class query forum (directors mailbox, Webmaster mailbox, retrieval mailbox, etc.)

The class module is made up of:

- * Various instructional units.
- * Various pages with class academic information with data related to the module.
- * One page of the class summary with the module summary.
- * Various pages of the class conceptual navigation map (the first map and the last).

The instructional class unit^{vi} consists of:

- * Various pages of academic information with data connected with the instructional unit.
- * One page of the class summary with a general summary of the instructional unit.
- * Various pages of the class conceptual navigation map (the first map and the end of the unit).
- * Various pages of the class forum (queries and discussion forum).

* Various pages of the class content (the core article central and the complementary pages).

It is also specified in the instructional unit diagram that the course has three types of instructional units:

- * Theoretical instructional unit.
- * Practical instructional unit or workshop.
- * Seminar-type instructional unit.

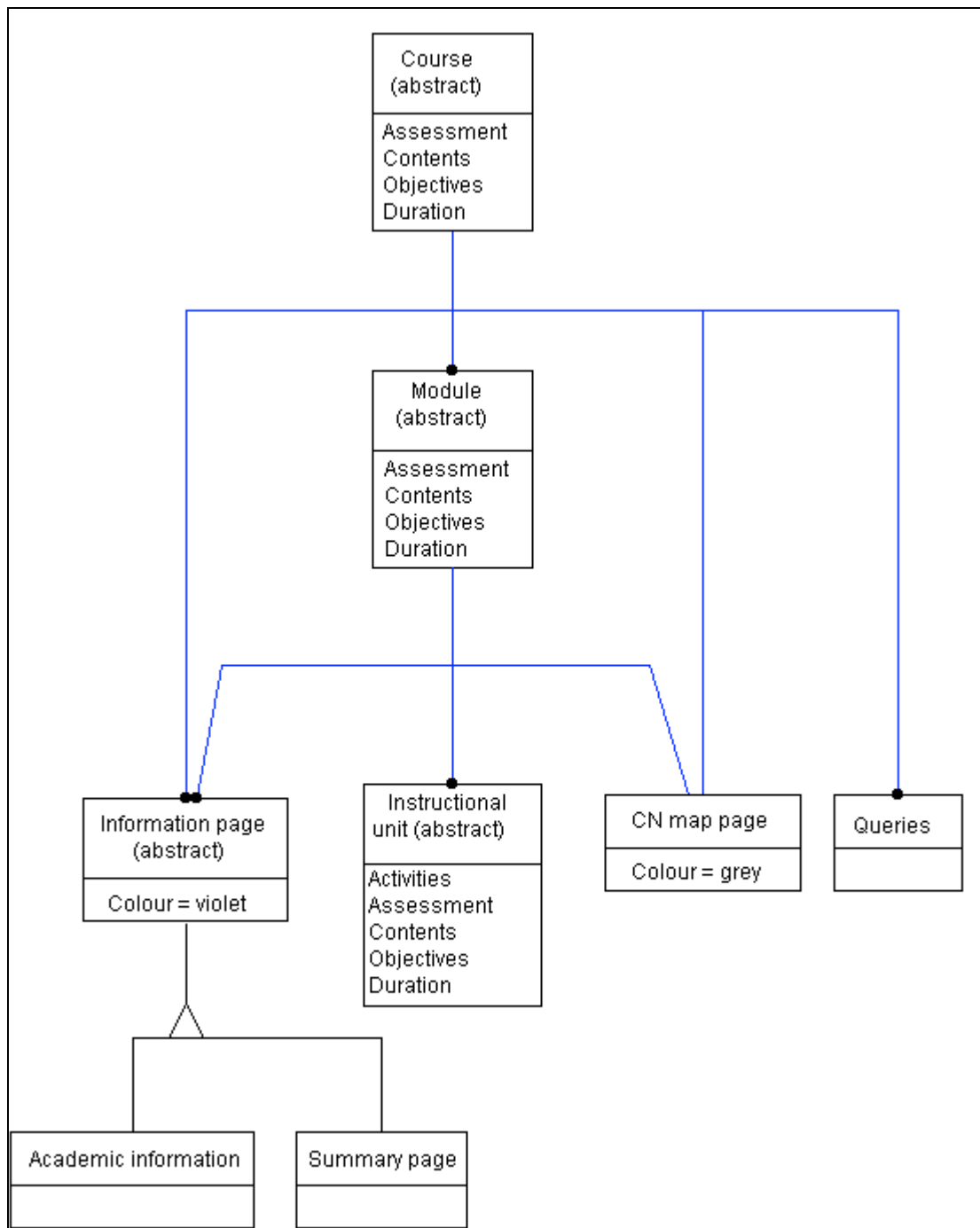


Illustration 5. Component parts of the course and class modules

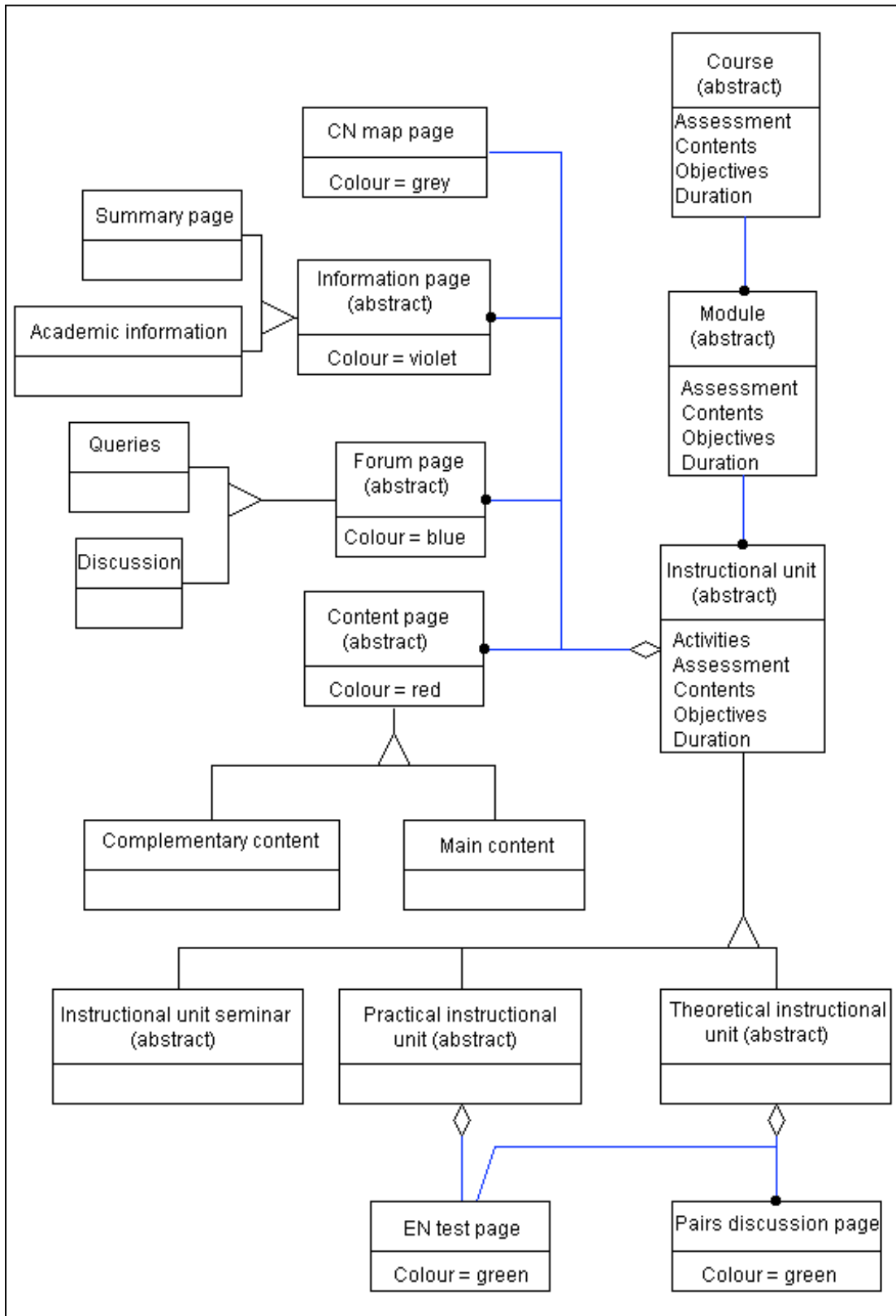


Illustration 6. Component parts and type of instructional unit class

3.2.3 Navigation system representation

The object oriented class diagrams permit help systems to be shown to hypertext navigation by means of a new hypertext link listing added to this representation system.

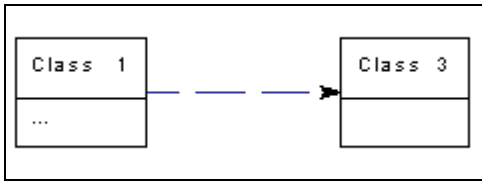


Illustration 7. Adaptation of OMT modelling to represent the hypertext link.

Four page fragment navigation systems and two page navigation systems have been designed in the Online Master in Digital Documentation.

Table 2. Classification of the navigation systems of the Online Master in Digital Documentation

Class type	Class
Page fragment	<ul style="list-style-type: none"> • Fold-out summary • Graphic summary • Text summary • Hierarchical branch
Page	<ul style="list-style-type: none"> • Conceptual navigation map page • Summary page

In the representation of the graphic summary^{vii}, a class diagram and an instance diagram show pages involved in this summary. In the hierarchical branch^{viii} representation, a diagram of instances is used to show the hypertext links involved in the hierarchical branch of the core article of an instructional unit, specifically unit 1.1.

The object oriented class diagrams allow combined perspectives to be shown which show different aspects of the same system. For example, navigation routes^{ix} between classes can be shown at the same time that the components of the classes involved with their respective attributes are represented on the instructional design.

Illustration 10 shows three possible navigation routes between the course class and the instructional unit class through the module class. This is a good example of the superfluity of options in navigation design for enabling different ways of moving through hypertext.

- * Route starting from the conceptual navigation map page.
- * Route starting from the navigation system of the fold-out summary.
- * Route starting from the summary page.

The diagram in illustration 11 shows the return journey from the summary page of the instructional unit to the course summary page. There are up to four possible navigation routes in the case of the latter:

- * Route starting from the conceptual navigation map page.
- * Route starting from the navigation system of the hierarchical branch.
- * Route starting from the navigation system of the fold-out summary.
- * Route starting from the navigation system of the graphic or text summary.

In this type of combined perspective diagram, the same notation allows elements of navigation design and instructional design to be represented by considering the hypertext instruction materials as information systems and modelling these systems in accordance with object orientation.

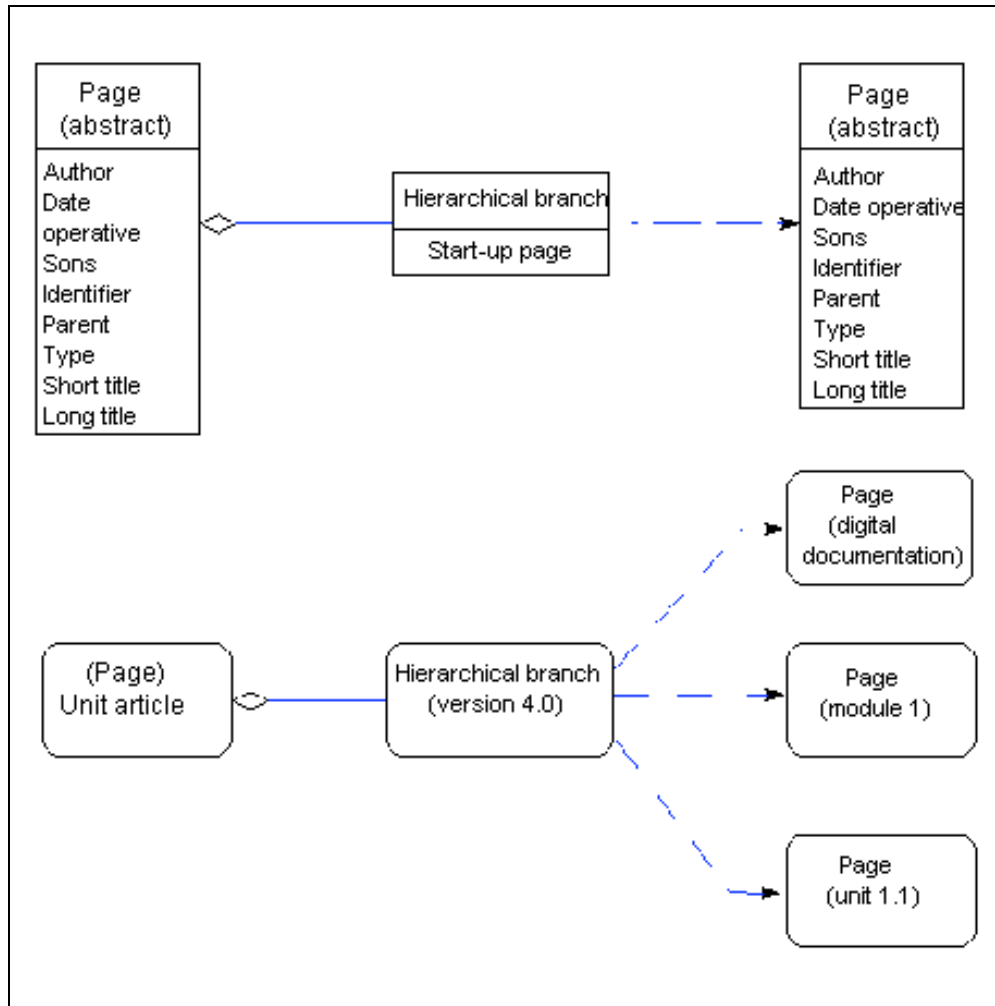


Illustration 8. Diagram of classes and instances in the hierarchical branch.

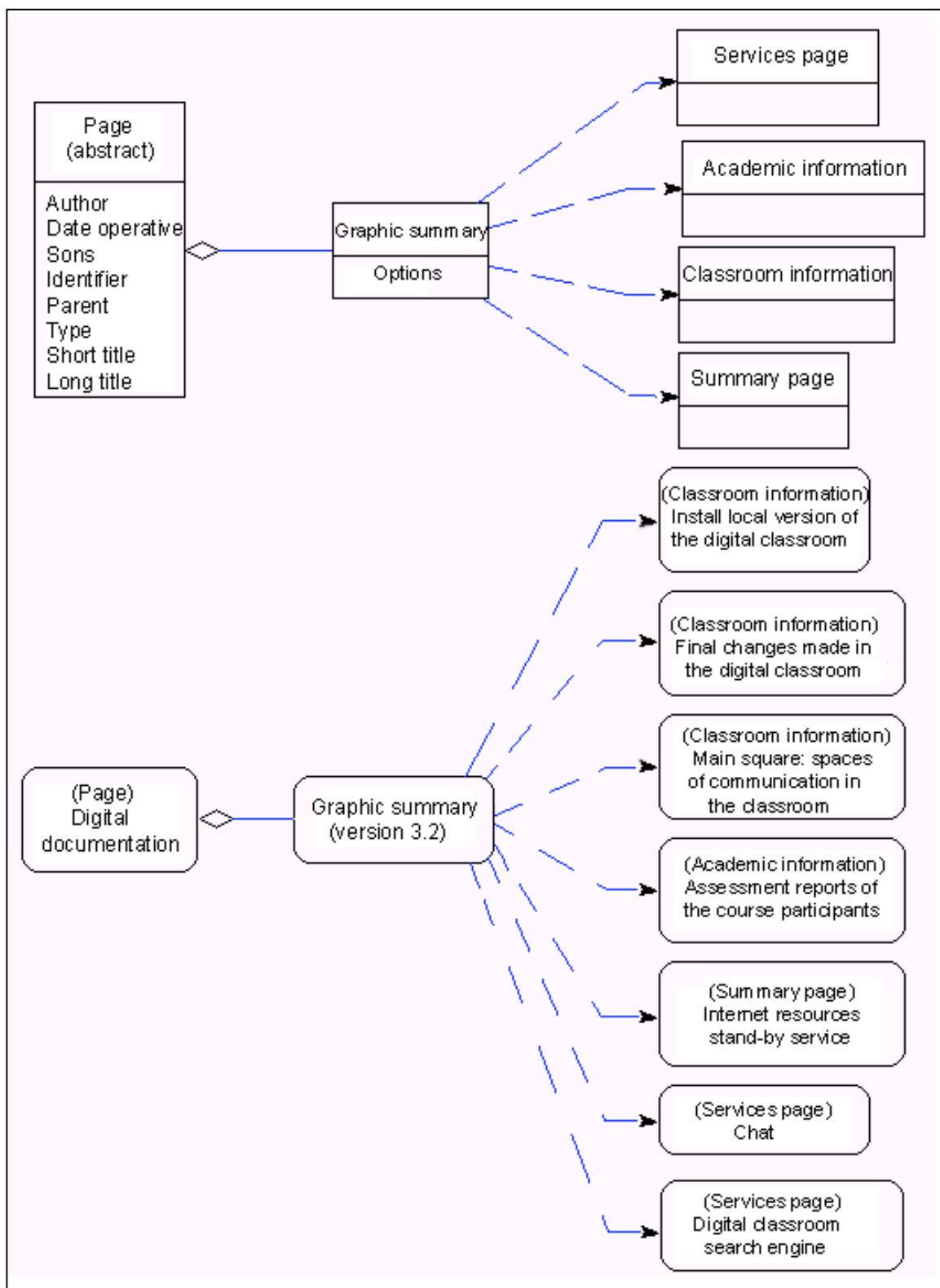


Illustration 9. Diagram of classes and instances in the graphic summary

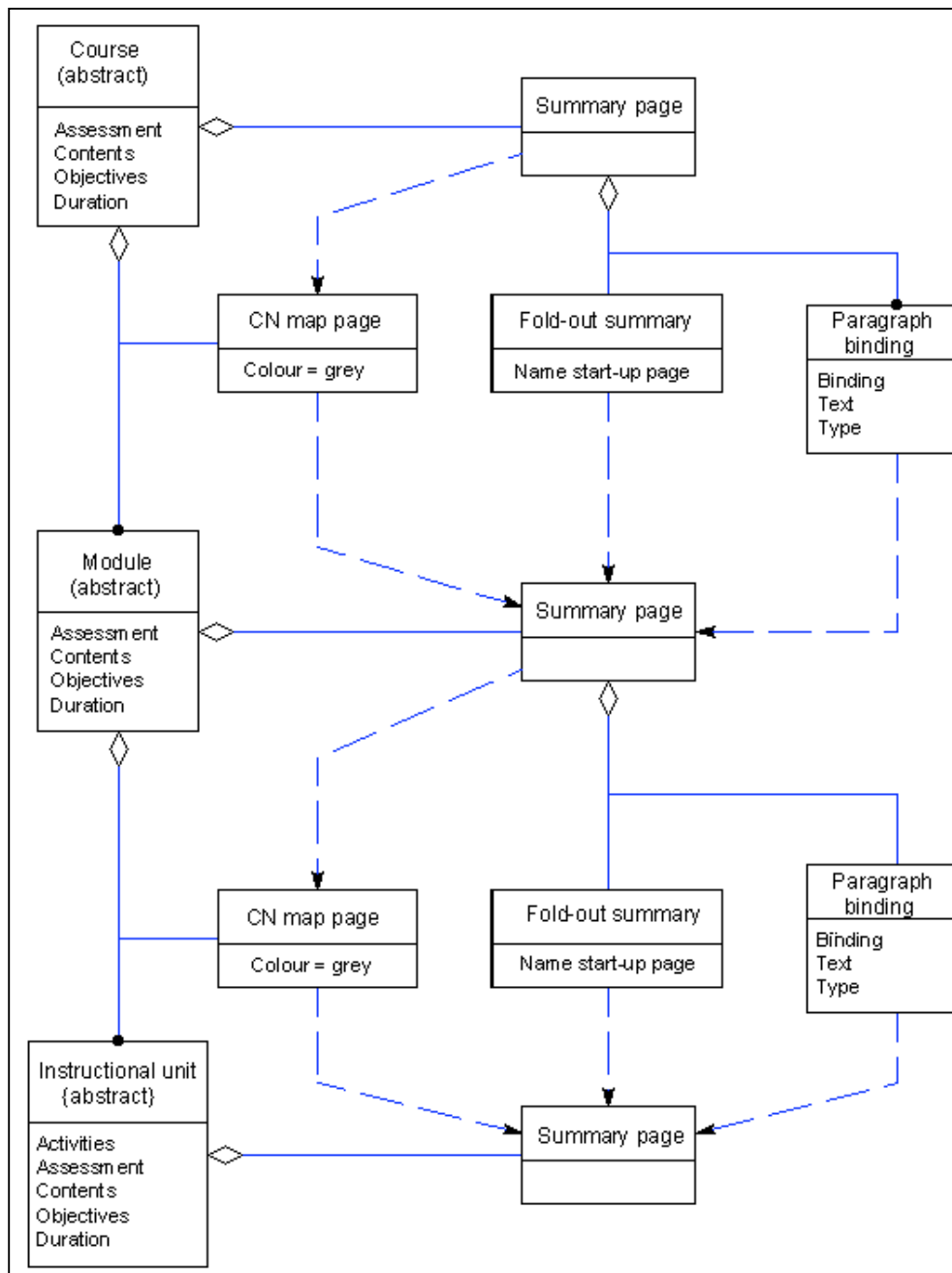


Illustration 10. Navigation routes from the course summary page to the summary page of an instructional unit.

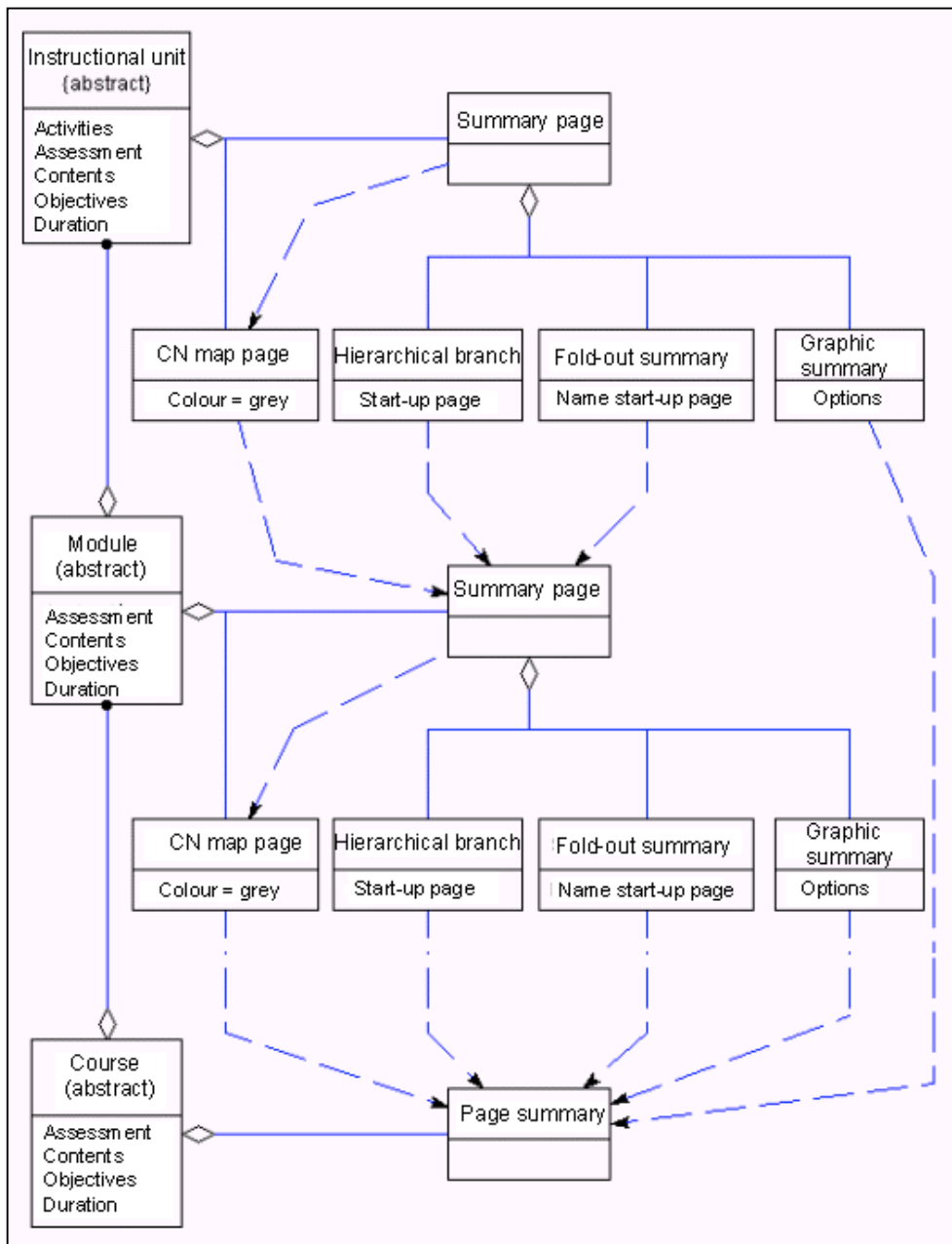


Illustration 11. Navigation routes from the summary page of an instructional unit to the course summary page

4. Conclusions

MAIDHEA is a method for modelling or representing hypertext for instruction and learning. It is the result of experience over five years in developing instruction materials for the Online Master in Digital Documentation. MAIDHEA is based on the methodology of object oriented information systems analysis and design and is useful in the process of developing hypertext instructional materials, especially when implemented with Web technology and Web page formats. A MAIDHEA diagram is an integrated way of representing navigation tools and systems, information structure and instructional design that are implicit to instruction materials.

5. References

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Notes

ⁱ See illustration 1. OMT symbols applied to the modelling of hypertext teaching materials.

ⁱⁱ See illustration 3. Diagram of the component parts of the class page where paragraph types are shown.

ⁱⁱⁱ See illustration 4. Class page type.

^{iv} The diagrams have been made using the Simply Objects editor in keeping with the notation of OMT object oriented design methodology.

^v See illustration 5. Component parts of the class course and module.

^{vi} See illustration 6. Component parts and type of class instructional unit

^{vii} See illustration 9. Diagram of classes and instances in the graphic summary.

^{viii} See illustration 8. Diagram of classes and instances in the hierarchical branch.

^{ix} See illustration 10. Navigation routes from the course summary page to the summary page of an instructional unit and Illustration 11. Navigation routes from the summary page of an instructional unit to the course summary page.