Hypermedia and the Web
An Engineering Approach

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For my wife Cathy and my parents John and Joan, you have my love always - your encouragement and support are unceasing.

David

To Pete - without whom this would not have been possible

Wendy:
Foreword

This rich, multi-faceted book is particularly appropriate at this time. Hypermedia is changing from a cottage industry of hand-crafted pages to a spectrum of applications that culminates in enterprise-wide systems. The intuitive, trial and error methods that have worked in the past do not meet today's needs, much less those of tomorrow. As the authors state, what is needed is an engineering approach - "a systematic, disciplined, and quantifiable approach to the development, operation, and maintenance of hypermedia applications." In this book, they explore what such an approach would look like, and they show how it could be applied to a hypothetical hypermedia design problem. They also discuss several systems that are alternatives to the Web and exhibit capabilities not found in it.

The book is really three books in one. Each is interesting and worthwhile in its own right. But, true to the concept of hypermedia, the authors weave the parts into a coherent whole by returning throughout to a few basic themes -- product, process, and cognitive load. Each time, the theme is viewed from a different perspective, expanding the reader's understanding of the depth and diversity of the issue.

Product is concerned with the tangible nature of a hypermedia application. It includes the various forms of information, such as text, graphics, and sound, their basic organization, the associations that link the various parts, and different modes of access, such as searching versus browsing. A key issue for hypermedia engineering is to develop an abstract representation of the application that can be scrutinized, tested, and ultimately implemented. As a starting point, they draw on software engineering models, but they show that a richer, more complex set of techniques will be needed for hypermedia products than those currently available.

Process is concerned with methods and techniques for building the hypermedia application, described in the product model, in a systematic and predictable way. Again, their starting point is software engineering. They explore characteristics of both the waterfall and the spiral, iterative models. But, again, they argue that there is currently no process model that is adequate for hypermedia engineering. For example, there is no good approach for long term maintenance of a hypermedia database. By recognizing the limitations of available approaches and by developing new techniques to achieve specific hypermedia objectives, a viable process model will gradually emerge, but it will not happen overnight.

Whereas Part I examines issues from a conceptual point of view, Part II applies those insights in a sustained way to a hypothetical problem - the HyperBank is updating its operations from conventional to hypermedia technology. The discussion of product considers how to choose a particular model in which to develop this application and lists the many different kinds of documents needed to specify aspects of it. The discussion of process considers both the waterfall and spiral models, how they could be applied, and differences in the design process that would result from using one versus the other. The authors also consider the overall
organization of information, the link structure that binds the parts of the site together, and the look and feel of the user interface.

In much of the research coming from the non-Web hypermedia community, WWW is treated in a begrudging fashion. The authors of Hypermedia and the Web: the Engineering Approach do not fall into this trap. They take pains throughout Parts I & II to show how the principles and practices they are considering can be applied to large, complex Web sites as well as to hypermedia applications implemented on other platforms. Developers of Web sites will find a wealth of useful information and reflection. However, lest they leave with impression that the Web is the only technology in which a site can be built, the authors include discussions of several other hypermedia systems.

Part III provides an in-depth look at five research projects - Microcosm, Matilda, Hyperwave (formerly Hyper-G), RMM and AHM. The first two of these were developed by the authors. They also consider a number of other systems and architectures in less detail. These chapters will be particularly informative for readers whose only exposure to hypermedia has been through the Web. They also note several of the more important limitations of WWW, such as its lack of support for authorship and links that break, and point out that these limitations have been overcome in other hypermedia systems. Since several of these alternatives have Web interfaces, designers have the option to build their sites within them, taking advantage of their additional features, while providing access through a conventional Web browser.

Whereas Part III could have been written as a separate exhibition of non-Web hypermedia systems, the discussions are continuously tied into the larger fabric of the book. For example, the authors point out specific ways in which these systems lend themselves to product and process models. They note features in an application design that are supported by some systems but not others. And they discuss how several of these systems address cognitive load for factors such as navigation.

Thus, the book is a richly diverse tapestry of design and development considerations. Issues are examined in the abstract, with respect to a sustained hypothetical example, and finally in relation to several systems that complement the World Wide Web. Readers will not find a "cookbook" set of procedures that can be applied mechanically. But if they invest the time and effort to ponder these issues along with the authors, they will emerge with a much deeper, more nuanced understanding of them. Should they be confronted with designing a hypermedia application at some future time, they will do so with a great deal more confidence and understanding than they would otherwise.

We may eventually achieve an engineering discipline that will allow us to build, operate, and maintain large hypermedia sites in a systematic, disciplined, and quantifiable way. We don't have that discipline today, but the authors have sketched a vision of it and they have shown us a path we can follow to start building it. Let us hope that others will join their effort and help them achieve that goal.

John B. Smith,
Chapel Hill, NC
April, 1998
In fact, every time one combines and records facts in accordance with established logical processes, the creative aspect of thinking is concerned only with the selection of the data and the process to be employed, and the manipulation thereafter is repetitive in nature and hence a fit matter to be relegated to the machines.

(As we may think, Vannevar Bush)

There has recently been a strong focus on the burgeoning information revolution. As a number of enabling technologies (such as communications networks, databases, and computing hardware) continue to evolve and mature, the ability to quickly and easily access information improves. Hypermedia and Interactive Media systems, such as CD-ROMs and the World Wide Web have provided a platform for allowing these technologies to be widely used, and have experienced phenomenally rapid growth in both usage and potential.

The result is that we have an unprecedented ability to rapidly obtain and utilise information from a growing range of sources. This glut of information is reaching the stage where the time required to absorb and analyse it is becoming prohibitive. Many people are finding it increasingly difficult to maintain relevancy. A typical problem which now exists is that we have access to so much information that we are finding it difficult, if not impossible, to sift through it and identify those areas which are relevant to us.

This problem is particularly visible with the World Wide Web, where we have vast quantities of information interlinked. The information scope which is immediately accessible is no longer bounded by a single document site or personal Web page, but covers the entire Web - often in a transparent fashion.

This problem is not likely to be easily resolved. If we are to avoid being “drowned” in this sea of information then we need to improve our techniques for using these information sources. Hypermedia is a tool which allows us to organise information in a way which is more in accordance with the ways in which we naturally access and manipulate information.

For hypermedia to be effective we must develop techniques for effectively creating quality hypermedia applications. This book is based upon the belief that a systematic, disciplined, quantifiable approach - in short, an engineering approach - to the development, operation, and maintenance of many hypermedia applications is essential. We hope to provide the

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1 As an example of the rapid growth of the Web, a survey carried out by SIMBA Information Inc, a leading market research and media company, suggests that the Web-only revenue from advertising is estimated at US$110 million in 1996 and is expected to rise to US$1.86 billion by 2000.
foundations upon which necessary skills, knowledge and understanding of hypermedia systems engineering can be developed.

The focus in this book can best be described by using an analogy (one which we will develop in more detail in Chapter 1). Much of hypermedia and Web development is very analogous to software development thirty years ago. Traditionally software applications were largely hand-crafted, tools were focussed around implementation and performance issues, almost no process modelling or management existed and metrics were primitive or non-existent. As software applications grew in scope and complexity this ad hoc approach broke down, leading to a phenomenon known as the ‘software crisis’. Many applications failed to meet their specifications or were completely unmaintainable. Over the next twenty to thirty years this was, and still is being, addressed through the development of software engineering development paradigms, process modelling and management, metrics, development methodologies and techniques, quality assurance, and a range of other activities which support the development process. Demonstrated gains include improved software quality and reliability, improved development visibility for both management and users, increased user confidence and satisfaction, reduced software development and maintenance costs and better management control.

Unfortunately hypermedia and Web development is currently at the stage that software development was thirty years ago. Most applications are developed using an ad hoc approach. There is little understanding of development methodologies, measurement and evaluation techniques, development processes, application quality, and project management. The focus in much of the development is usually squarely on technical issues such as interface implementation. Rarely is the development process adequately considered or understood. It these problems which this book aims to begin to address. Like software engineering texts, this book will not provide an explicit approach. Indeed such an approach does not yet exist, and it may not even be appropriate to provide a general approach for all types of hypermedia development. Rather, this book focuses on the issues which we need to understand in order to undertake effective development and provides pointers as to the directions in which we should be heading if we are to effective manage the development of hypermedia and Web applications.

Underlying the ideas in this book are two primary emphases. Firstly, that hypermedia development is a process. This process includes more than just media manipulation and presentation creation. It includes analysis of needs, design, management, metrics, maintenance, etc. The second emphasis is the handling and management of information in order to achieve some desired goal. The context of this book is the combination of these two emphases - the utilisation of a suitable process in creating hypermedia applications which are effective in managing and utilising information.

Before we look at the aims of this book in more detail it is worthwhile making explicit very early that in this book we have somewhat of a love-hate relationship with the World Wide Web. The Web is by far the most significant existing platform for supporting delivery of hypermedia and interactive multimedia. Over the last few years it has become ubiquitous and is now both widely utilised and widely abused. We would be remiss in this book of we did not provide a degree of focus on the Web and it’s technologies. At the same time however, we recognise that the Web has some quite fundamental flaws with respect to supporting flexible open hypermedia systems. Because of this we often criticise the Web (rather mercilessly in places) and applications or websites which utilise web technologies. It should nevertheless be kept in mind throughout the book that even where we criticise the technologies which underlie the web or the way in which these technologies are used, we still recognise the pre-eminence of the Web as a vehicle for supporting hypermedia. Indeed, much of Part II is about how we can develop applications which overcome the flaws of the Web. This is, in essence, the origin of the title of the book - we focus on both hypermedia
and the Web, and how an effective engineering approach to development can result in quality applications, irrespective of possible flaws in the underlying technologies.

**Goals of the Book**

*Hypermedia and the Web* has essentially three primary goals:

**To provide a resource which can lead to significantly improved development.** In this book we aim to provide both an understanding of hypermedia development which will lead to improving current practice. Whilst definitely not a ‘how-to’ guide for any particular tool, package, authoring environment, or platform, this book can be viewed as a general ‘what-to’ guide for hypermedia development. In other words, this book looks at what aspects need to considered during the development process. It looks at what the issues are which affect decisions made. It looks at what we can do to substantially improve our current practice.

**To engender an awareness of the need for a more disciplined approach to the development of hypermedia.** We strongly believe that hypermedia development needs to move from the current largely *ad hoc* approach to development to a more disciplined approach. If this is not achieved then we shall increasingly find that large complex applications are not delivering the expected performance or quality, and that the development process becomes increasingly complex, difficult to manage, and expensive. In this book we wish to develop an awareness of these problems and an understanding of the implications if they are not effectively addressed.

**To demonstrate how the field is likely to evolve over the next five years.** Finally, we recognise that the hypermedia field is evolving very rapidly. What is best practice now is likely to be outdated and uncompetitive within a very short span of time (certainly less than a few years, and probably measured in months). As a result, any book such as this would be quite remiss if it did not develop (in parallel with developing an understanding of current best practice) an understanding of how hypermedia development and development best practice is likely to evolve within the foreseeable future. A major goal of this book is to show how those development issues which are still problematic are likely to be addressed, and the implications for how development will be carried out in the future.

**Who should read the Book**

This book considers the hypermedia development process and how to perform hypermedia development in a way which is consistent with sound engineering principles. This book considers current practice and trends, issues affecting the development and usage of hypermedia applications, and discusses and demonstrates best practice. The book should therefore be of interest to anyone involved in any of the broad range of development activities within hypermedia. This includes anyone involved in application development, media capture or creation, user interface development, application analysts and designers, information experts, Web developers and managers, content experts, and project managers. In all of these cases, an appreciation of the role of specific activities within the overall development process would be of significant benefit.

The book provides significant interest for designers of hypermedia applications and those managing such projects. Examples include the development of CD-ROMs and Websites on company intranets. The book will look at how concepts of handling information are likely to affect the development process and how the information can be effectively structured and
accessed. In particular, aspects related to how information can be reused, and how applications can be maintained are likely to affect how hypermedia applications are designed.

Content and interface experts need to be aware of the way in which text, graphics, sound, video, images, etc. are used within hypermedia applications in order to understand what content is most appropriate in a particular context and how best to structure and present this information. This book will help develop an understanding of how structuring and presentation can be most effectively achieved now, and how the field is likely to change over the next 5 years. Authoring architectures, techniques for managing large complex information spaces and information modelling are some of the key concepts covered here.

This book should be of interest to both researchers and practitioners. For researchers it will show current trends and provide an overview of the areas which are still open research questions. For practitioners, it will demonstrate current approaches to development and show how they can be most profitably improved and applied. It also considers directions in which the field is heading, provides insights into aspects which need to be considered, and provides a strong understanding of the types of systems which are likely to be used in the future.

Finally it is worth mentioning that it is assumed that the reader has some familiarity with at least the fundamentals of hypermedia and multimedia (such as experience with the World Wide Web). Beyond this basic assumption, little or no technical knowledge is assumed of the reader.

**Outline of the Book**

We have begun by claiming that we need to develop a discipline of what we have referred to as ‘hypermedia engineering’. The goal of this book is to begin this process by outlining practical steps which can be taken in setting up a development process which adheres to current best practice, and has the greatest achievable probability of resulting in high quality hypermedia applications.

This book is broken into three parts. The first part (chapters 1 to 6) covers the fundamentals of hypermedia engineering and development. If we are to develop hypermedia applications effectively then we need to have a strong understanding of the structure and goals of hypermedia applications.

We begin in chapter 1 by explaining the need for a discipline of hypermedia engineering. Then in chapter 2 consider what exactly we mean by the term ‘hypermedia’. We provide both a historical context, and a goal-based perspective and end with a working definition of hypermedia which can be used to guide our approach to the development of hypermedia applications. In chapter 3 we look at how we represent both hypermedia information and the structure of hypermedia applications themselves. From here we consider what characteristics are typically built into hypermedia applications.

In chapter 4 we describe the development process and the concept of hypermedia engineering. We show that the goal of the development process is twofold: to develop hypermedia applications which have desired characteristics, and to undertake this development as effectively and efficiently as possible. Hypermedia engineering provides us with a mechanism for achieving this goal.

Chapters 5 and 6 look at the issues which must be addressed during the development process. These are separated into product issues (chapter 5) and process issues (chapter 6). Product
issues are those which must be considered during the development which have a direct or indirect impact on the quality of the product (as perceived by a user and relative, of course, to the requirements of the applications being developed). Process issues are concerned with the effectiveness of the development process itself. Examples include factors which affect development productivity and repeatability.

The second part of the book (chapters 7 to 9) applies the fundamentals developed in the first part of the book to showing how hypermedia applications can be most effectively developed.

We look at the errors, pitfalls, and failings which are common when creating hypermedia applications and show how they can lead to difficulties either in the development process itself (such as runaway budgets, blown out timeframes, or loss of development focus) or with the resultant product (such as unusable or inadequate interfaces, poor performance, and incorrect, incomplete or badly structured information). We also show how these problems can be circumvented. We look at current best practice within the constraints of current understanding and technology. We provide practical tips, hints, and recommendations which have the potential to significantly improve the effectiveness of current development practice and the quality of developed applications. We also identify the (many) problems and issues which even best practice has yet to adequately address. In the final chapter of part 2 we consider future directions in hypermedia engineering and development and how we may be able to overcome those difficulties which still remain.

The third part of the book looks at a number of existing research and development projects. This is intended as a vehicle for demonstrating how the field of hypermedia may evolve, and how many of the existing problems with hypermedia development can be overcome. Each of the projects considered demonstrates how specific issues in the development process can be addressed.

In the final chapter of the book we revisit many of the concepts covered, and finish with some crystal ball gazing.
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Part I

Hypermedia Development Fundamentals

Hypermedia cannot truly develop as an effective communications medium until we are able to develop applications which not only assist in information procurement, but also facilitate effective information utilisation. This requires an understanding of, on the part of developers, the issues which need to be addressed during the hypermedia development process, and appropriate approaches for addressing these issues. In this book we have an underlying focus on the need for a development process which has been devised with a consideration of managing information and its uses in communication. We call this ‘hypermedia engineering’. This is distinct from a current strong focus on managing media rather than information. Although information management has been the focus of much work on hypermedia applications, usage, interaction, etc. it has only recently been actively considered during the full life-cycle development process. The book illustrates why this trend is critical to the continuing evolution of hypermedia applications and our ability to effectively develop these applications.

This first part of the book introduces hypermedia applications and hypermedia development (including hypermedia authoring) and focuses on the issues which need to be addressed during the development process and current theory as to how this might be achieved. In particular, the information management and communication aspects which are addressed during the development process are considered. In order for hypermedia development to evolve and improve (both in terms of application quality and process success) we need to improve the way in which we currently approach managing, storing, manipulating, accessing and representing information and its structure.
1. Introduction

_The essence of knowledge is, having it, to apply it; not having it, to confess your ignorance._

_(Confucius)_

**Key Issues and Goals of this Chapter:**

This chapter aims to introduce the book and provide a context for the book overall. In particular we wish to develop an understanding of hypermedia and Web, the current crisis which exists with respect to their development, and the critical need for a more disciplined approach to development of these applications - an approach which we refer to as Hypermedia Engineering. The key points considered in this chapter are:

- A common understanding of hypermedia is developed in order to establish a consistent framework for later discussions.

- A rudimentary taxonomy of hypermedia applications is considered, in order to define the domain of interest of this book.

- The characteristics of large scale hypermedia applications are considered and it is shown how these relate to the development process.

- The development process of hypermedia is compared to software development from 30 years ago - and the conclusion is drawn that we are in the midst of a crisis!

- We introduce the concept of “Hypermedia Engineering” and how it can help us develop an effective approach to development, thereby improving the crisis.

The above quote was chosen to begin this book since it so neatly encapsulates what hypermedia has, to date, failed to achieve. Hypermedia, the conjunction of hypertext and multimedia, undoubtedly has incredible potential as a vehicle for improving our ability to effectively utilise information. Unfortunately, hypermedia, and especially its ubiquitous incarnation as the Web, has to date only just begun to fulfil this potential.

Current hypermedia applications are beginning to mature in their ability to support the first aspect of the above quote - “The essence of knowledge is, having it”. The more advanced current applications do provide reasonable access and retrieval of information, albeit often within a constrained domain. They do not yet, however, help us achieve the second half of the problem - appropriate application of the knowledge or information.
2. Hypermedia

We live on an island surrounded by a sea of ignorance.  
As our island of knowledge grows, so does the shore of our ignorance.  
(John A. Wheeler)

Key Issues and Goals of this Chapter:

In this chapter we take a much more detailed look at what exactly we mean by the term ‘hypermedia’. We provide both an historical context, and a goal-based perspective and end with a working definition of hypermedia which can be used to guide our approach to the development of hypermedia applications. The key points considered in this chapter are:

- We look at cognitive aspects of hypermedia to begin to develop an understanding of the underpinning philosophy.
- Numerous existing definitions are analysed. We see that these tend to have a technology focus, and do not help us understand the implications for development.
- We derive a definition for hypermedia which helps us understand how to effectively develop hypermedia applications.
- Once we have a definition, we consider in more details the goals of hypermedia. In particular the concept of hypermedia as a vehicle for information utilisation is established.
- A solid understanding of information concepts and how they relate to hypermedia is developed.

What is hypermedia development? This entire book is about hypermedia development, and yet the term is not yet well understood or defined, even within the research and academic literature. Individual books, papers, documents, manuals and presentations use the term to cover a surprisingly diverse mix of activities. These include, though are not limited to, media management (such as data capture, storage and manipulation), creative and artistic processes (such as content design and interface creation), implementation activities (such as the use of both ‘authoring’ and presentation tools and development languages) and application development (such as hypermedia application design, process planning, and development process management).

Before we can begin to consider this broad array of activities and the roles they play within the development of hypermedia applications, we need to understand exactly what we mean by
If you don't know how to do something, you don't know how to do it with a computer.
(Anonymous)

Key Issues and Goals of this Chapter:

Having developed an understanding of hypermedia in the previous chapter, we now focus on the modelling of hypermedia information. We aim to show how we represent both hypermedia information and the structure of hypermedia applications themselves. From this point, later chapters will be able to consider what characteristics are typically built into hypermedia applications - and therefore how we approach their development. The key points considered in this chapter are:

- The functionality of the digital domain is considered, especially with respect to how we can represent and manipulate data. This leads on to a consideration of support for hypermedia interactivity.

- We develop an understanding of the types of information structures which can be constructed and how these structures help us manage information.

- We look at current hypermedia models, and how these models help us understand how to represent information, and how to create applications which work within the constraints of these representations.

- A detailed understanding of the characteristics of hypermedia applications is developed, and in particular we look at how different characteristics help achieve the goals of hypermedia applications.

Hypermedia applications are about helping users manage data, information and knowledge in a cohesive manner. Hypermedia development systems help developers create applications which achieve this. We have shown that an understanding of information is important to our understanding of hypermedia. From a pragmatic perspective, hypermedia is about managing knowledge. But knowledge management will be controlled by our ability to manage and represent information. In the development process which we use to create applications we need to consider how this might be achieved. Managing information will, in turn, be controlled by our ability to manage and represent data. Again, we need to consider how to achieve this.

Management and representation of data is becoming increasingly well understood. Mechanisms for representing audio, image and video data are being progressively refined...
4. What is Hypermedia Engineering?

*The most original authors are not so because they advance what is new, but because they put what they have to say as if it had never been said before.*

*(Johann Wolfgang von Goethe)*

**Key Issues and Goals of this Chapter:**

From previous chapters we have developed a solid understanding of hypermedia applications and their characteristics. This chapter aims to develop an understanding of the development process and the concept of *hypermedia engineering*. We show that the goal of the development process is twofold: to develop hypermedia applications which have desired characteristics, and to undertake this development as effectively and efficiently as possible. Hypermedia engineering provides us with a mechanism for achieving this goal. The key points considered in this chapter are:

- A definition of the goals of hypermedia development is developed and the implications of this definition are considered in detail. In particular we differentiate between product issues - related to the application being developed - and process issues - how we go about creating that application.

- We develop a definition of *hypermedia engineering* which focuses on a systematic, disciplined, quantifiable approach to development.

- We consider those activities, technologies, or approaches which contribute to hypermedia engineering. In particular we consider process, paradigms, methods, activities, etc.

- We look at the activities which will typically be carried out in a hypermedia development project and how these are integrated into an overall process.

- Approaches to managing the overall process, and the issues which impact on this process are delineated.

We began Chapter 2 by asking the question “What is hypermedia development?” and both Chapters 2 and 3 were spent developing an understanding of the general concept of hypermedia. Having developed an understanding of hypermedia and hypermedia applications, we can now return to that original question of hypermedia development. We
Chapter 5

5. Obtaining A Quality Product

... not picked from the leaves of any author, but bred amongst the weeds and tares of mine own brain.
(Thomas Browne)

Key Issues and Goals of this Chapter:

At this point in the book we have developed an understanding of the need for, and the basic elements of hypermedia engineering. In this chapter we want to begin to develop a detailed understanding of how the development process impacts on the quality of the application which we develop. The key points considered in this chapter are:

• We begin by defining the twin concepts of product issues (those issues in the development of applications which impact on the quality of the end result - such as navigability) and process issues (those issues which affect the quality of the process itself - such as development productivity).

• We define a comprehensive set of process and product issues and then look at the product issues in detail.

• We look at application relevance as being the extent to which the application is pertinent to it’s intended goals. The relevance is affected by understanding the domain and suitable design methods.

• Completeness and correctness of an application are addressed through suitable design techniques, as well as understanding the application goals.

• Usability of an application is addressed by effective structural design, inclusion of appropriate navigation and searching mechanisms, and a good understanding of user-interface design.

• Other issues addressed include supporting information utilisation and helping with user cognitive loads.

In the previous chapter we introduced the concept of hypermedia engineering. We viewed hypermedia engineering as being the formal and disciplined approach to the development of hypermedia application. We detailed a number of the activities which may be part of this process, and how the process itself may be structured.
6. Obtaining A Quality Process

*Action to be effective must be directed to clearly conceived ends.*
*(Jawaharlal Nehru)*

**Key Issues and Goals of this Chapter:**

In the previous chapter we looked at factors in the development which impact on the quality of the applications which we develop. In this chapter we aim to develop a strong understanding of the factors in the development which impact on the quality of the process itself - in other words, how we achieve an effective, productive, high-quality process. The key points considered in this chapter are:

- Development productivity is impacted by both the productivity achieved in individual activities (such as content generation) and the ways in which these activities are inter-related.
- Managing the cognitive burden of the developer is critically important.
- Reuse of media is common. Reuse of information and processes is extremely uncommon. This is a major problem!
- Maintenance of hypermedia applications tends to be very fine-grained and very poorly managed.
- Managing the development process for hypermedia development is currently somewhat of an art which requires much further work to achieve reasonable levels fo understanding.
- Hypermedia process measurement is almost non-existent, but potentially extremely important in improving current practice.

In the previous chapter we considered a broad range of product issues which need to be addressed during the development process. These issues were those which related to the quality of the application being developed, it’s ability to achieve the goals of hypermedia applications. Let is revisit the definition we provided on the goals of hypermedia development:
Part II

Hypermedia Development Practice

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University of Southampton, U.K.

Part 1 of the book focused on developing an understanding of the underlying principles and issues in developing hypermedia applications. Part 2 will focus on how to carry out practical development in a way consistent with this understanding. We will look at best practices within the constraints of current understanding and technology, and provide a basis for developing an approach to the engineering of quality hypermedia applications. We also identify the (many) problems and issues which even best practice has yet to adequately address.

We begin part 2 of the book by developing (in Chapter 7) a framework within which we can discuss practical approaches to the development of hypermedia applications. We also consider issues which impact on the overall approach to the development: especially product and process models and planning the development process. In Chapter 8 we look in general at the development process and consider each of the development phases. In Chapter 9 we then consider specific issues and techniques which can contribute to the hypermedia-specific aspects of the development process.
7. Development Process

*Plans get you into things but you got to work your way out*
*(The autobiography of Will Rogers (1949))*

**Key Issues and Goals of this Chapter:**

Part I of this book focused on the fundamentals of hypermedia engineering. Part II will focus on practical development. In this chapter we aim to provide a framework for the overall development process. The key points considered in this chapter are:

- Hypermedia development is incredibly diverse. No single process will be uniformly appropriate. Indeed very few processes currently exist. Furthermore, there is currently only a poor understanding of what aspects are required in these processes.

- In order to develop an effective process, we need to understand the project! We should begin this by undertaking some form of domain analysis.

- A domain analysis includes understanding the problem, understanding potential solutions, and understanding any constraints on the development process.

- Based on our domain understanding we need to identify appropriate product models. A product model defines the architecture of our solution.

- Based on our domain understanding and our product model, we need to identify or adapt a suitable process model. The process model defines the approach which we take to development.

- Different process models are suited to different conditions. Risk is handled well by a spiral model. Uncertainty is handled well by prototyping and incremental development.

- We can use our process model to plan the appropriate activities and outcomes of the development.

In earlier chapters we considered what is meant by the term development and looked at factors and issues which affect how we carry out development. We now wish to look at the specifics of how we carry out development, i.e. what should be occurring in current practice. In this chapter we look at the broad issue of how the development process can be identified and managed, and what types of development processes are appropriate.
Key Issues and Goals of this Chapter:

In the previous chapter we looked at development processed in a somewhat abstract sense. In this chapter we aim to provide an understanding of the activities which can form the components of these processes. The key points considered in this chapter are:

- The development stages are not necessarily linear, or even distinct.
- Analysis aims to help us understand the problem, the users, the content, the context, the structure, etc.
- Design takes a set of requirements and converts these into a description of an application which can be created. The critical aspects of design are the information structuring and creation of access mechanisms. Design often makes extensive use of prototyping.
- Application production is typically a relatively mechanism task (apart from the graphic design elements) but is usually very time consuming.
- Verification of applications is exceedingly important but poorly understood and often overlooked.
- Maintenance is very important for hypermedia development but is often ignored during the initial development, resulting in applications which become stale very quickly and are extremely difficult to maintain.

8.1 Introduction

In the previous chapter we looked at how the development process can be planned and managed. As we discussed, the process typically begins with some form of domain analysis (involving consideration of the problem, solution and development domains). The outcome of this analysis is a suitable product model (or a high level architecture for the hypermedia system), a process model, and an instantiation of these into a project management plan and a frame work for documentation.
9. Development Techniques

There is always a best way of doing everything, if it be to boil an egg
(Emerson, “Behaviour”, The conduct of life (1860))

Key Issues and Goals of this Chapter:

Chapter 8 looked at the stages of development and how they are combined. In this chapter we go deeper into the practicalities of how the development might be carried out. Although we cannot provide a cohesive methodology (it will be different for every project, and the field is still not mature enough to be able to be so prescriptive) we can provide certain guidelines. The key points considered in this chapter are:

• The important activities in analysis are elicitation of information and formulation of the requirements. Techniques such as interviews, questionnaires, brainstorming, scenarios, and prototyping are all useful.

• Structuring of information is one of the few activities where formal methods are beginning to appear. The use of these depend on the type of information and whether legacy data exists.

• Designing of associative links can be incredibly time consuming and is currently difficult to manage other than manually.

• Design of searching and indexing methods can utilise well established techniques from database systems and information science.

• Design of application look and feel is still largely an art rather than a science.

9.1 Introduction

In the last chapter we looked at the development process in general and the various activities we have to carry out within the development process. In this chapter we will look in detail at how to carry out some of the hypermedia specific activities.

We have mentioned a number of times that some of the activities we have to perform are common to other disciplines of engineering such as software engineering and systems engineering. These activities are in the areas of analysis, planning and coding (in the case of
Part III

Hypermedia Research Developments

Many of the issues which we have raised in the first two parts of this book are still open research questions. Hypermedia development is still a young and evolving discipline, and as such there are numerous areas where we do not yet have a sufficient understanding. There are numerous research groups around the world which are undertaking cutting edge research into many of these areas.

In this final part of the book we provide an overview of a number of current hypermedia research projects. In particular, we look at how these research projects provide insights into how many of the addresses raised in this book are likely to be addressed in future systems, development tools, and development approaches.
10. Current Research

Research serves to make building stones out of stumbling blocks.
(Arthur D. Little)

Key Issues and Goals of this Chapter:

In this part of the book we are looking at development projects which provide an insight into some aspect of hypermedia development. This chapter aims to explain why this is important, provide a set of criteria which can be used to guide our analysis of cutting-edge projects, and begin the process of considering various research and development projects. The key points considered in this chapter are:

- Looking at cutting-edge research and development can provide us with valuable insights into how to improve hypermedia development practices, and how these practices may change in the future.

- There is very little research currently being carried out on improving hypermedia development practices. Indeed there is often an attitude (misguided in our opinion) that this is unnecessary.

- We have defined various important questions which can guide our consideration of cutting-edge research and development.

In this section of the book we will be looking at a number of research and development projects. It may seem strange to be considering research projects in a book which is trying to discuss and promote best practice in hypermedia development. There are however several very good reasons for this.

Firstly, the hypermedia field (and especially the Web) is changing so rapidly that what is research now can quickly become practice tomorrow. In such a dynamic field it is important to be aware of the potential evolutionary (and possibly revolutionary) changes which may occur in even a short time frame. Secondly, although specific research projects may not become mainstream, they are still able to provide indications of how field is likely to develop. Alternatively they may provide useful hints or concepts which can be adapted for specific practice, or provide a more thorough understanding of specific development problems or issues and how to handle them.
11. Matilda, MGraphs and MIST

Who’ll come a waltzing Matilda with me
(Waltzing Matilda, A. B. Patterson)

Key Issues and Goals of this Chapter:
Matilda is a hypermedia framework, associated information models and tools, which focuses on scalable information representations. This chapter aims to show the importance of an effective information model and how this can impact on the development approach. The key points considered in this chapter are:

- Matilda is based around a novel representation which separates application independent information from application dependant information. The representation is intended to highly scalable.
- The Matilda representation makes extensive use of abstractions of information to support flexible browsing.
- Matilda does not actively address development process, but the model and the tools which are based on it have an implicit process.
- A major goal of the Matilda project us to actively support reuse of information.

11.1 Introduction

The Hypermedia and Visual Information Applications (HyVIS) research group within Computer Applications Engineering at the University of Technology, Sydney is engaged in research in hypermedia information modelling, approaches to large-scale hypermedia development, use of image data in hypermedia, hypermedia databases, computer vision, image and video representations, image quality assessment, and related topics.

In this chapter we wish to primarily discuss several related projects from this research group: the Matilda hypermedia framework, the MGraph hypermedia information model, and the MIST information structuring tool.
12. Microcosm

Everything is deeply intertwined
(Ted Nelson)

Key Issues and Goals of this Chapter:

Microcosm is one of the most successful open hypermedia systems. This chapter aims to show how a flexible approach to the management of not only content but also structure can simplify many aspects of the development. The key points considered in this chapter are:

- Microcosm is an open hypermedia system which separates management of links from management of content, and places no requirement for markup on content.
- A core goal of Microcosm was to reduce hypermedia authoring effort.
- Microcosm actively supports the concept of generic links - links which relate to general content which can appear in numerous specific locations.
- Microcosm is based on an architecture which utilizes numerous filters which can manipulate links (and hence structure) in very flexible ways.
- The Microcosm approach is particularly effective for managing both content and flexible access to this content.

12.1 Introduction

The question the Microcosm team set out to tackle was, and indeed still is, how do you set about building fully cross-referenced versions of very large electronic archives and information repositories? A fuller discussion of the original motivations for the Microcosm project can be found in [60], which includes a description of the team’s initial work with the Mountbatten archive.

The problem was approached from the team’s background in building resource-based applications using hypermedia systems. When dealing with very large information systems, it was considered that the main issues for the hypermedia designer/author were the problems of working with very large numbers of documents and links, the increasingly highly multimedia nature of electronic information, and the fact that different users will approach the information repository from different perspectives. In collections of unstructured
13. Hyper-G and Hyperwave

Structure without life is dead. But life without structure is un-seen

Key Issues and Goals of this Chapter:

Hyper-G is a client-server internet based hypermedia system which provides session support, access control, and a rich data model. This chapter aims to demonstrate ways in which an alternative system to the Web can provide functionality which improves both usability and development. The key points considered in this chapter are:

- Hyper-G, like the Web, is client-server based. Unlike the Web connections to servers are maintained for the duration of a session. This allows more effective access control and logging
- Hyper-G has adopted a rich data model which includes links between flexibly defined anchors and document collections (which form a document hierarchy).
- Hyper-G document collections allow contextualisation of information.
- The Hyper-G anchor-link model allows flexible management of non-text media and maintenance of link consistency
- Hyper-G has evolved into HyperWave - a system which inter-operates with the Web but provides most of the advanced information management features of Hyper-G.

13.1 Introduction

Hyper-G was conceived in 1989 at The Institute for Information Processing and Computer Supported New Media (IICM) at the Graz University of Technology. During the 1980’s IICM had been undertaking research on videotex systems and hypermedia in the form of Computer Aided Instruction systems. Using this experience, the idea was conceived for a system which combined the expertise which had been developed in these areas, yet circumvented their design problems (such as the confusion of content and structure). The result was Hyper-G. The developers of Hyper-G claim “Hyper-G represents the first of a new generation of Internet information systems -- it provides real hypermedia, supporting tools for structuring, maintaining and serving heterogeneous multimedia data including text,
Key Issues and Goals of this Chapter:

The Amsterdam Hypermedia Model amalgamates ideas from hypertext and multimedia. The goal of this chapter is to demonstrate how different media can be effectively integrated in a way which supports contextualisation of information and management of temporal media. The key points considered in this chapter are:

- The Amsterdam Hypermedia Model combines the Dexter model of hypertext with the CMIF model of multimedia.
- AHM supports composition of multiple media, including temporal media, into flexible presentations with synchronisation between the media.
- AHM allows the specification of link contexts, whereby the behaviour of different components of a presentation, upon following a link, can be specified. This allows improved contextualisation of presentations.
- CMIFed provides a flexible tool for efficient creation of multimedia presentations.

14.1 Introduction

The Interoperable Multimedia Applications group at CWI (Centrum voor Wiskunde en Informatica) in Amsterdam, Netherlands has been researching into multimedia and hypermedia for a number of years. The group is working on authoring software for hypermedia presentations (both implementations and theoretical models) and on operating application and network support for multimedia and hypermedia, in particular synchronization of independent streams. A major focus of the group’s work is on developing models and authoring environments which result in flexible interoperable and portable hypermedia applications.

In this chapter we will discuss two related research contributions from this research group: the Amsterdam Hypermedia Model (AHM), and the CMIFed authoring tool. The Amsterdam hypermedia model is an amalgamation of basic principles from both the
15. RMM

...before I had executed half of my design, for the Machinery was entirely wanting to complete it.
(Epistle Dedicatory, Alexander Pope)

Key Issues and Goals of this Chapter:

The Relationship Management Methodology (RMM) provides an approach to the design of hypermedia structures. This chapter aims to demonstrate how a formal approach to the structural design of hypermedia systems can provide significant benefits, especially in terms of productivity and application quality. The key points considered in this chapter are:

- RMM is based on the adaptation, from software development, of entity relationship modelling. It provides steps for modelling the entities in an application, the organisation of these entities, how this is used in supporting navigation, design of user-interfaces and run-time behaviour design.

- RMM makes explicit a process model, but the model only covers a limited range of the full development process activities.

- RMM utilises a design model (RMDM) which provides a basis for representing the resultant application design.

- RMM provides an effective methodology for the class of applications which are highly structured and have high volatility.

15.1 Introduction

Work undertaken primarily within New York University’s Stern School of Business has been investigating aspects of hypermedia technology and especially related to its applications and development processes. In this chapter we will focus on one particular project - the Relationship Management Methodology (RMM) developed by a group of researchers including Isakowitz, Stohr, Balasubramanian, and Diaz [71, 72].

RMM has been described by its developers as a methodology for the structured design of hypermedia systems. It is essentially a design model and a set of specified design steps which aim to provide a methodology for creating hypermedia applications. The design model is based on a combination of the use of entity-relationship diagrams, and various
16. The Future of Hypermedia Engineering

*Only connect*
*(Howards End; chapter 22, E. M. Forster)*

**Key Issues and Goals of this Chapter:**

This is the concluding chapter of the book. We aim to finish by providing various insights into possible future directions in which hypermedia may evolve, and how we can work towards more effective development. The key points considered in this chapter are:

- **Currently the Web is the dominant hypermedia system in use. The Web is evolving very rapidly. Unfortunately development practices are not evolving nearly as quickly.**

- We can identify three primary product models for hypermedia applications: the publishing model, the presentation model, and the distributed information management model.

- **The tools and approaches for managing the development of hypermedia applications are yet to reach any degree of maturity.**

- **A consideration of issues for the future can help us understand potential directions in which hypermedia may evolve, and therefore give insights into how we can develop applications.**

- **We mustn’t lose sight of fact that development, or even hypermedia itself is not an “end”. It is only a “means” for providing information for the sake of developing knowledge which can be utilised. Development should be carried out within this context - something which is often overlooked.**

**16.1 Introduction**

In this book we have tried to establish a case for viewing large-scale hypermedia developments as an engineering enterprise and to draw analogies and similarities with the evolution of the software engineering approach to large-scale program development. As more and more people and organisations grapple with the complexities of developing and
Appendix 1:
Design Principles

A1.1. Design Principles

A large number of Hypermedia design checklists and guidelines exist, especially with respect to the Web. During this book we have discussed a number of these design principles. In this appendix we have summarised the more significant of these. It is important to note that the justification for these principles various from supporting cognitive studies to research analysis to current practical experience. In all cases they must be considered in the broader context of the application goals.

We have not attempted to be exhaustive in this list (there will, after all, always be yet another principle which could be added to cater to specific circumstances). Nor have we tried to categorise the following principles. Indeed, we have simply tried to provide broad principles (with an explanation) instead of specific rules. For example, we state “keep interfaces simple” rather than “avoid scrolling text”.

Indeed, the following list is simply intended as a starting point which could be used in at least two different ways. Firstly, it should give a starting point for developing a feeling for good hypermedia design practice. Secondly, the following list could be used as a checklist for design reviews. It is also very important to keep in mind that the following principles should always be used within the context of a suitable development process.

<table>
<thead>
<tr>
<th>Principle</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manage bandwidth resources effectively</td>
<td>Making extensive use of images, audio, animations etc can place heavy burdens on resources - especially communications bandwidths. This can in turn slow down access. Consider alternatives such as using smaller images (and possibly providing a link to the full-size image) and thumbnails, limiting animations, using image and audio file formats which give compression etc.</td>
</tr>
<tr>
<td>Keep screen design simple</td>
<td>Many hypermedia applications suffer from overly complex screen design. This gives an opportunity to demonstrate coding skill, but results in applications which are confusing and difficult to use to locate appropriate information. As an example, use screen backgrounds which do not detract from the foreground content.</td>
</tr>
</tbody>
</table>
Appendix 2: Development Activities

The following is a list of possible development activities which can be incorporated into the development process. Note that the specific groupings given (such as ‘management’) are not necessarily the most appropriate for a specific process.

**Management**

Management activities are those activities which contribute to the overall supervision and organisation of the development process. These activities will typically ensure the adequate progression of the development.

**Project initiation:** This involves the initial concept development, selection of a process and methodologies to follow, and development process initiation. This will often occur in response to a perceived market niche, need or opportunity.

**Project planning:** Covers organisation of activities, timing, work schedules, coordination of resource and skills allocation, and specification of deliverables. This will often involve the use of conventional project management tools (such as project planners, and management tools such as GANTT charts). To be performed effectively this requires an awareness of both the activities required for a successful development process and the resourcing required by specific activities. At present this is often based only on experience or general heuristics (such as “1 hours of educational content typically requires 10 hours of authoring effort”).

**Project management:** This encompasses the usual project management operations, such as initiation, coordination, evaluation and administration of activities (typically based on the project plan).

**Budgeting:** Cost analysis and prediction, expenditure management, etc. This will require an awareness of the cost of resources (including ‘hidden’ costs such as personnel recruitment costs). This will often be particularly difficult as the skills required for effective development are changing rapidly and typically on the cutting edge of the technology (and hence in short supply and subject to wide variations in cost).

**Resource management:** This covers resource analysis, resource procurement, allocation, evaluation and utilisation. Different resources will be needed for different development activities. For example, a single computing platform may be needed for the bulk of the development work, but access to a range of platforms may be needed for evaluation purposes. Physical resources include computing hardware (such as computers, scanners, displays, network hardware, storage media, backup facilities), media capture tools (such as video and photographic cameras, and audio equipment), physical space (“where will the content experts work?”) and personnel. Logical resources include time, money, and skills.

**Personnel management:** The effective management of the personnel involved in a development effort is a major concern. This includes analysis of skill requirements (such as
Appendix 3: Development Plans and Checklists

The following sections contain both typical outlines for documents resulting from typical development activities and checklists which provide a basis for developmental reviews. It is important to note that the document outlines given are not necessarily intended to be used "as-is". Rather they should be adapted to suit specific circumstances, or used as an indication of the type of issues which need to be addressed.

Much of the information for these plan and checklists derives from the systems and software process management literature. In particular, “Software Engineering Fundamentals” [9] is invaluable for further reading.

A3.1. Application Development Plan

<table>
<thead>
<tr>
<th>Table A3-1: Typical hypermedia application development plan outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Document scope</td>
</tr>
<tr>
<td>II. References, Terminology, Acronyms</td>
</tr>
<tr>
<td>III. Application description</td>
</tr>
<tr>
<td>content, functionality, interfaces, project deliverables</td>
</tr>
<tr>
<td>IV. Contract description (if appropriate)</td>
</tr>
<tr>
<td>contractual commitments and obligations</td>
</tr>
<tr>
<td>V. Product model selection</td>
</tr>
<tr>
<td>VI. Development process selection</td>
</tr>
<tr>
<td>process selection, adaptation, management methodologies</td>
</tr>
<tr>
<td>VII. Work breakdown</td>
</tr>
<tr>
<td>project tasks, development activities, reviews roles</td>
</tr>
<tr>
<td>VIII. Scheduling</td>
</tr>
<tr>
<td>timing of tasks and activities, milestones, reviews</td>
</tr>
<tr>
<td>responsibilities</td>
</tr>
<tr>
<td>IX. Resourcing</td>
</tr>
<tr>
<td>resources (physical, personnel, skills, time, tools)</td>
</tr>
<tr>
<td>resource management</td>
</tr>
<tr>
<td>X. Risk management</td>
</tr>
<tr>
<td>risk identification, risk management</td>
</tr>
<tr>
<td>contingency planning</td>
</tr>
<tr>
<td>XI. Project management</td>
</tr>
</tbody>
</table>
Appendix 4: Example Case Study

HyperBank

In order to illustrate many of the ideas presented in this book we have used a case study as the basis of various examples. The following is the scenario used as the basis of the case study.

The ABO (Archaic Banking Organisation) is a large commercial banking organisation which provides a broad range of banking products and services and has a large varied customer base. The types of information with which the ABO deals is incredibly diverse, both in domain and in structure. Examples include:

- Account information (such as account ownership and transaction details). This information is enormous but is very well structured and is currently maintained using traditional database technologies. Dedicated software systems are used to provide interfaces to the systems designed to handle transactions, statement mailouts etc.

- Mailouts (such as announcements and bimonthly newsletters to customers). The bimonthly newsletter is managed by the ABO’s public relations office, and is outsourced to a small specialist publisher. The remainder of the material is handled in an ad hoc fashion as required.

- Advertising material (such as television and radio advertisements, posters, brochures, and pamphlets). As with the bimonthly customer newsletter, this is outsourced to a third party advertising agency.

- Procedure manuals (such as guidelines for tellers). The bank has a large set of standard paper manuals outlining operating procedures for bank staff. These manuals have been developed using an eclectic mix of technologies scattered through various bank departments.

- Employee information (such as staff details and employment conditions). These are typically maintained by the ABO’s personnel department. The employer details are stored in a database which has interfaces to software systems such as salary and retirement fund details. Conditions of employment and related information is managed in various ad hoc fashions.

- Administrative information (such as phone lists and contact names). An internal customer developed text-based system is used to support access to a number of regularly updated lists of information such as phone lists, contact names in bank branches, and staff availability. In addition, an internal email system is also supported.
Bibliography


4 Apple Computer (1989) *HyperCard stack design guidelines*. Addison-Wesley


