DIANE\textsuperscript{nx}:
Modelling Navigational Exploration in the Web Context

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ABSTRACT

The process of exploring is an important aspect of a user’s general understanding of the environment they are navigating through in computational systems. A majority of research has examined the exploratory behaviour of user’s within an application or game based context. The research outlined in this thesis presents common exploratory behavioural aspects in the web context. An experimental approach was conducted involving observations and interviews of participant’s exploratory behaviour within structured and unstructured websites. Furthermore, it was observed and derived from the reviewed literature, the use of four navigating methods employed by humans in the physical and web environment. The findings indicated similarities to application and game contexts exploratory behaviour. The findings included themes of exploratory behaviour based on semantic matching, task formation, page aesthetics, and frustration. Moreover, defined navigating methods were indicated by a backward and forward tracking process, search facilities, and navigational aids usage by participants.

Existing task model research and development has focused on the analysis and modelling of interactive systems for both systems and user interaction, modelling the necessary actions required. In this research, DIANE\textsuperscript{RX} task model, based on DIANE+, was developed to enable the modelling of exploration within the web context. An exploratory criteria was developed from the empirical findings providing the creation of operations for the DIANE\textsuperscript{RX} exploratory task model. The DIANE\textsuperscript{RX} task model enables user interface and web designers the ability to model exploration performed by user’s within the web context. Furthermore, a two-phase modelling process was defined to enable designers to understand where common deviations were made from the designers intended page path for the task under observation.
DECLARATION OF ORIGINALITY

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person where due reference is not made in the text.

Signed:

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Today’s Date: Friday 31st October 2003
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Chapter 1
INTRODUCTION

1.1 Background

The use of task analysis and modelling in the Human Computer Interaction community has long been applied in the design of interactive applications, and is generally used in user interface design and evaluation to ensure the usability of computational systems. It represents the acquisition of actions performed by the user, system, or both that are required for a particular task associated to the system under evaluation. A task model can be used to represent the intended actions required, or evaluating a user’s set of actions under observation. However, little has been done in applying and modelling, using task models, exploratory concepts of a user’s task exploration within computational systems.

Exploratory behaviour in computational systems is different depending on the type of system the user is exploring. A substantial amount of research has been applied within the traditional application and game contexts. The observation of user’s exploring in these studies has provided several key behavioural findings. The findings have included aspects based on task formation, a user’s approach to randomly trying things, remembrance of commands and surroundings, and frustration. Furthermore, the process of exploration is not possible without a form of navigation. Therefore the use of navigation and psychological navigating methods such as landmark, routes and maps play an important role in navigating in the physical and computational world. Moreover, navigation is placed within two navigation environments, based on familiarity and visual cues recognised by the navigator: structured and unstructured environments.

More research is required into the understanding of exploratory behaviour in the web context. The concepts obtained can then be applied within a task model, providing the
ability to model a user’s interaction between the system during exploration and used in the evaluation stage of websites in the software development life cycle.

1.2 Overview

This research aims to develop a task model that allows designers at the evaluation stage of a website to model a user’s task exploration based on the exploratory behaviour observed. The modelling will provide designers with the ability of understand the process to exploration throughout the defined task and the possible deviations that occur from the intended task pages.

The research question “How can a task model be extended to capture navigational exploration in the web context?” was developed, and is the driving force of this research.

Furthermore, from this question it could be seen that an understanding of exploratory behaviour and navigation concepts performed by users is required for the development of operations in the task model. Therefore, an experimental research approach was taken, including observations and face-to-face interviews of exploration performed by users in the web context. From this an exploratory criteria was developed based on the concepts obtained from the experimental data collection approach. This criteria feeds the development of the exploratory task model formalism (DIANE\textsuperscript{nx}), which was built upon an existing model DIANE+’s inability to model exploration. Furthermore, a two-phase modelling process was introduced, enhancing the model’s ability to consolidate deviations from multiple user explorations. Finally, an analytical evaluation of the proposed model against navigational page data obtained from user observations was performed, providing an indication of the capabilities of the exploratory task model.
1.3 Objectives

The objectives of this research are intended for both the Information Systems research and practice community:

IS Research Community:

- To provide more insight into user exploration in the web context and exploratory behaviour, in both structured and unstructured environments.

- To extend the existing purpose of task analysis and modelling to incorporate exploration within computational systems.

IS Practice Community:

- To provide a powerful tool for user interface and web designers to analyse and model a user’s navigational exploration in the web context. Furthermore, recognising the importance of exploration and a user’s exploratory behaviour within the web context enabling improvements within sites structure and other aspects.

1.4 Outline of Thesis

The content of the thesis is presented in 8 chapters. A description of each chapter is outlined below:
Chapter 2 Literature Review
Outlines the literature undertaken for the motivation and rationale of this research. Furthermore, concepts in exploratory behaviour and navigation are presented and are used throughout this thesis.

Chapter 3 Research Methodology
Introduces the research design conducted, consisting of an experimental approach. Data collection and data analysis techniques are also presented.

Chapter 4 Empirical Findings
Presents the empirical findings obtained from the experimental approach.

Chapter 5 DIANE$^\text{nx}$: The Exploratory Task Model
Discusses the development of the exploratory criteria, the DIANE$^\text{nx}$ formalism and two-phase modelling approach. Furthermore, a discussion on DIANE+'s inability to model task exploration is presented.

Chapter 6 DIANE$^\text{nx}$ Task Scenario Walkthrough
A scenario walkthrough of the DIANE$^\text{nx}$ formalism and the two-phase modelling process, obtained from the analytical evaluation of DIANE$^\text{nx}$ formalism against collected navigation page data in the experimental approach.

Chapter 7 Discussion
Presents a discussion on the empirical findings in relation to the literature review. Furthermore, a discussion on the DIANE$^\text{nx}$ formalism is presented.

Chapter 8 Conclusion
This chapter presents the limitations of the findings, future research, and contributions to the Information System’s community, both in research and practice.
Chapter 2
LITERATURE REVIEW

To provide a clearer definition of exploration and the concepts that are employed by users of computational systems, and possible relations to the web, a review of work in exploratory behaviour literature, the acquisition of navigating methods, and the existence of navigating environments is synthesised. Furthermore, reviewed literature in task analysis and modelling, along with the chosen task model for representing exploration within the web context is presented. This formed the focus and development of the research question.

2.1 Exploration in Computational Systems

It is quite clear that many web users surf the net with the intention of enjoying the process of exploration. However, the process of exploring and the motivation to explore can be quite different in the game, application and web based computer systems. A majority of research into exploring computational systems has focused on the game and application, with minimal empirical research in the web environment (Waern & Soto 1999; Whitaker 1997; Rosenfield & Morville 1998).

Several definitions of exploration in computational systems have been presented. Whitaker (1997) refers to exploration as a journey and a type of navigation known as educational travel, where the process of moving through space is its own goal. Furthermore, Whitaker (1997) advocates that exploration involves the acquisition of situation awareness. Situation awareness is the continuous extraction of environmental information, integration of this information with previous knowledge to form a coherent mental picture, and the use of that picture in directing further perception and anticipating future events. In contrast, Benyon and Hook (1997) mention the use of knowledge formation and advocate that knowledge in exploration is knowledge in the world, and not
knowledge in the explorer’s head. These definitions seem to fall within similar concepts, the use of environment and the acquisition of information to form knowledge from the exploring environment.

2.2 Exploratory Behaviour

The environments presented in computational systems can be categorised into three types; applications, games and the web context. Furthermore, there are two major characteristics of computational exploration: its navigational structure and the intended output from exploring the system.

The navigational structure of computational systems provide the user with the ability to explore (Whitaker, 1997). A distinctive difference between the web and application contexts, are the complex navigational structures available in the web environment (Rosenfield & Morville, 1998) enabling you to move freely among information spaces, in comparison to a flat navigational structure (i.e menu) that exists in applications (Howes, 1994). Moreover, in the three-dimensional game context, the navigational structure is three-dimensional using all aspects of the physical environment we live in, producing a similarity and possible attractiveness to explore in the artificial environment. Therefore, it could be suggested that the web provides similarities to games, representing a 3D information space in a 2D structure with the possibility of exploring an infinite space.

In addition, there are several exploratory behaviour concepts obtained from exploring a system. Rieman (2003) and Waern (1987) advocate that exploration is task-driven in the application context, and users postpone their exploration until given a real-task. However, unlike adventure games, people are drawn into exploring through the fascination and realistic navigational surroundings that are provided. Furthermore, Carroll (1990) describes an application as a tool, where the output is a work product, providing a substantial reason why application based exploration is generally task-driven. Whereas
the game is a toy and the output is to have fun with a more abstract goal in mind (Carroll, 1990).

Rieman (1996), Barton and Draper (1993), and Soto (1999) studies discussed additional observed aspects of exploratory behaviour from users primarily using application-based systems:

- If prompted to generally explore, users engage in random things to try whilst exploring all menu options first (Barton & Draper, 1993).
- Exploration as stated above is task driven and users are generally determined and efficient when it comes to getting their work done (Soto, 1999).
- Although most users explore what they need to know and nothing more (Soto, 1999) users generally do not remember a command output even after figuring it out and revisit misunderstood commands (Barton & Draper, 1993).
- Soto (1999) advocates that users mental mechanisms are excellent in figuring out complicated things from very little evidence.
- Barton and Draper (1993), and Rieman (1996) observed that users get frustrated and even stuck by minor problems in the user interface, such as semantic menu item matches with the task description.

Furthermore, in terms of the user’s goal Barton and Draper, (1993), and Soto, (1999) observed that users explore in pursuit on how to do a novel task, or experimenting with a navigational component (or command) to see what it does. Therefore, it can be concluded from these concepts that there are two forms of exploration in computational systems: the user is exploring to discover, or the user is exploring to achieve a specific goal.
2.3 Human Navigating Methods

The above exploratory behaviours are not possible without a form of navigation. The use of navigation plays an important role in enhancing exploration. Users can easily get lost or disorientated in large hypertext structures such as the web (Hammond, 1993).

Dillion et al. (1993), Raskin (2001), Boling (2003) and Whitaker (1997) discuss the psychological aspects of navigation on the basis of three methods which people use to navigate towards a goal. They are landmarks, route finding, and map/survey knowledge. Furthermore, Boling (2003), Whitaker (1997) and Raskin (2001) have discussed the possibility of humans applying these methods in website navigation.

Boling defines landmark as an identifiable feature of a general landscape and its use as a base. In the web context the landscape can be considered the website environment, its symbols, navigational screens, graphics and bookmarks as its identifiable features (Whitaker, 1997; Raskin 2001). Moreover, Boling discusses that users generally explore out from the landmark space and come back once they are lost or require a different direction. This is also known as traditionally the hub-spoke effect (Rosenfield & Morville 1998).

The route method can simply be defined as a logical set of links that form path between navigational pages (Boling, 2003; Whitaker, 1997). Whitaker details that humans do not remember features along the way and described them as abstract, they remember signs. In the web context these signs can be represented by informative, descriptive, and visible page titles or history list (Moyle & Cockburn, 2002), although it is unclear if these signs could be described as a series of pages that fall in-between the distinctive start and end landmarks of the route.

A map navigating method represents a spatial orientation and the relationships of one place to another (Boling, 2003). A website may facilitate this method by using site maps,
diagrammatic representations, list of links and breadcrumbs. Breadcrumbs show the location of a page within a site, and are generally represented by text and a separator, showing the path taken (Instone, 2003). This helps to give an overview of the path taken.

In addition to existing human navigation methods, Whitaker advocates a fourth method that appears on the web, which helps navigating both through various websites and pages within. Search facilities, such as search engines or page searches provide quick access to a specific landmark. Although this method is not present in the physical world and contributes very little to the cognitive map maintained by the user through exploration, it may partly replace the basic searching mechanism conducted by humans (Soto, 1999), providing quick access to a landmark.

Overall, the preceding physical navigational methods are clearly applicable in website navigation, although little has been done in modeling exploration facilitating these navigational methods in the web environment. A majority of exploratory behaviour experiments have focused on traditional applications, (Howes, 1994; Soto, 1999; Kitajima & Polson, 2003; Rieman, 1996; Draper & Barton, 1993) although key results obtained from these have provided some insight into general exploratory behavior.

### 2.4 Navigating Environments

In addition to the preceding navigating methods, Whitaker (1997) advocates two types of navigating environments that are present in the physical world and the possibility of their representation in the web context. These environments may result in different exploratory behaviour displayed by users in computational systems. They are structured and unstructured environments:

The structured environment is defined as providing unique landmarks along with a standard familiar structure that is associated to that particular environment (e.g. navigating through a city). The use of consistency throughout the site, (e.g. layout and navigational
aids) as the familiarity to other sites of the same type (i.e. information/organisational sites, search engines) may identify a structured web environment.

In the physical world an unstructured environment is a natural environment: it is less familiar to the navigator and requires different cognitive processes and cues. The process of navigating through a site containing links to various pages in no particular structured layout could be classified as unstructured.

It can be concluded from the above review that a deeper understanding of exploratory behaviour, including the use and representation of navigating methods in web based navigating environments is required. Furthermore, the modelling of these aspects will provide web designers the ability of capturing exploration, and therefore understanding how to improve the sites structure and aesthetics according to user exploration. Therefore, literature into task analysis and modelling was reviewed, for its use in modelling of exploration.

2.5 Task Analysis and Modelling

Task models describe activities that are to be performed so that user’s goals are attained. There are a number of task modeling formalisms that have been developed, each covering a specific phase of the Software Development Life Cycle (SDLC). The use of task analysis and modelling in the Human Computer Interaction community has long been applied in the design of interactive applications, and is generally used in user interface design and evaluation to ensure the usability of computational systems (Balbo et al. 2003; Bentley 2003; Paris et al. 2001). Task analysis and modelling may be performed at two levels of abstraction. High-level user task analysis providing designers with an understanding of the user’s point of view whilst using the system, and the lower system level that captures the detailed interaction of a sequence of interface events between the user and the system (Tarby & Barthet, 1996). The modelling of user exploration will
involve the extraction of user interaction with web-based environments, therefore a lower level of abstraction will be considered.

Several popular methods were reviewed for their potential capabilities of modelling exploration. Bentley and Johnston (2001) and Balbo et al. (2003) reviewed existing task modelling formalisms, providing a set of criteria and guidelines based on the SDLC, and other aspects for using task models in the given context. The MAD, UAN, GOMS and DIANE+ task models were evaluated:

The MAD task model is both a formalism and methodology for acquiring task knowledge from interviews with end-users (Bentley, 2000). The model is based on a hierarchical structured link of nodes by temporal and logical relations. Balbo et al., (2003) advocates that due to its primary purpose of contributing to user requirement analysis, it is intended to be used at the discovery and define stage of the SDLC. Furthermore, its hierarchical based structure may invoke difficulties in modelling the random actions of exploration.

On the other hand, the UAN (User Action Notation) (Hartson et al, 19990) method was created to formalise user actions for user interface designers and the development team, and models the user behaviour whilst using a system (Bentley, 2000). It holds similarities to MAD, in that it is based on a hierarchical decomposition of a task (Balbo et al., 2003). However, a major fallback is its use of tables and text in its formalism, no use of graphical representation, thus reducing usability of communication and modelling (Balbo et al., 2003).

In contrast to the preceding models, the GOMS (Goal, Operator, Methods, and Selection rules) family (Card et al. 1983); KLM (keystroke level modeling), CMP (Cognitive, Perceptive, and Motor Tasks) formalism is used in predictive evaluation for measuring performance in the evaluation phase of interactive systems (Balbo et al., 2003). However, its selection of notations, criteria, and non-use of graphical representations impede on its usability for both communicating and modelling for designers, therefore reducing its extensibility.
From the preceding models it can be seen that extensibility, the use of graphical notations, and usability for both communication and modelling are important aspects in choosing a model for exploration. Therefore, taking this into consideration, the DIANE+ formalism (discussed below) was the chosen model incorporating these aspects.

2.5.1 DIANE+ Task Model Formalism

DIANE+ (Tarby & Barthet, 1996) is used during the user requirement analysis phase of the SDLC, and it has a very powerful, formal representation of a task (Bentley, 2000). It was originally developed as a user-centered model, focusing on the user task and data (Paris et al., 2001). It is able to model the two levels of abstraction in task-based analysis; the system and the user, bridging the gap between software engineering and human factors (Paris et al., 2001).

DIANE+’s rich use of graphical operations to represent task decomposition, along with temporal and logical relationships, and the ability to model decomposition of tasks, give high usability for modelling and communication (Balbo et al. 2003, Paris et al., 2001). The formalism provides a wealth of features, such as, iteration and optionality of tasks, composite sub-tasks, the use of boolean operators, and clear actor representation (system, user, or interaction of both). The designer has the ability to model preconditions to express what state, mode, or situation is required to enable the task (Paris et al., 2001). System feedback and task termination can also be indicated explicitly in the formalism (Balbo et al. 2003, Tarby & Barthet 1996).

The preceding points indicate that DIANE+ provides a high amount of coverage in software engineering requirements in comparison to most popular task models, and can be adapted effectively to model different types of systems. Balbo et al. (2003) advocates that rich semi-formal graphical formalism provides high extendibility to express relationships or concepts not originally included, which will be important in extending
the formalism to incorporate added operations and processes for exploration in this research.

From the above review the following research question was developed, and will be the focus of this research:

“How can a task model (DIANE+) be extended to capture navigational exploration in a web context?”

2.6 Conclusion

This chapter presented the formation of the research question “How can a task model be extended to capture navigational exploration in a web context?”. It introduced an abstract definition of computational exploration, followed by aspects of exploratory behaviour in game and application-based systems. It was discussed that exploration is not possible without navigation, therefore navigating methods used by humans in both the physical, and possibly the web, were reviewed. It was also added the use of these methods in two navigating environments: structured and unstructured, and their representation in the web context. Finally, a discussion on possible task models was presented, concluding with the chosen DIANE+ formalism for exploration enhancement. In answering the research question, Chapter 3 discusses the formation of two subsidiary questions from the primary research question, and the research methodology employed for data collection and analysis in acquiring the answer to these questions.
This chapter outlines the research methodology applied. It introduces the research question and the formation of the subsidiary questions. The experimental research approach is presented and the observation and interview methods conducted. Furthermore, the participant sample is discussed and the research application. Finally, the data collection and analysis is presented.

### 3.1 Research Question

The aim of this research is to answer the following question:

“How can a task model (DIANE+) be extended to capture navigational exploration in a web context?”

As discussed in the literature review (Chapter 2), an understanding of user exploratory behaviour in both the structured and unstructured environments in the web context is required. This will provide similarities and differences in navigating methods and general exploratory behaviour. The gathered aspects of exploratory behaviour will provide an understanding of the techniques used during exploration in the web context, which can then be applied as operations to the exploratory task model formalism.

Therefore, the research question can be split directly into two subsidiary questions:

1. What aspects of exploratory behaviour in navigational exploration exist in structured and unstructured web environments?
2. What processes and operations are to be added to the existing task model that support exploratory behaviour in the web context?

3.2 Research Approach

The research aims to develop an exploratory task model that is built upon the DIANE+ formalism, therefore an understanding of user exploratory behaviour was required for the development of the task model’s operations. The research required an approach that gathered qualitative data on users exploration in the web context, therefore a snapshot in time approach was taken.

A positivist approach enables us to look at user exploratory behaviour through an empirical investigation. “Positivists evaluate an explanation by logically deducing from theory (based on scholarship) then collecting data and analysing it in ways that exclude alternative explanations, and that other researchers can reproduce” (Shanks et al 1993, p. 5). Moreover, the purpose of this study is explanatory, involving an understanding of the exploratory behaviour that is used within different web environments, which will form the development of operations in the exploratory task model formalism. Furthermore, due to the explanatory approach, there are three possible research approaches (Shanks et al): survey, case study, and experiment.

The survey research approach is a “..way of collecting data about a situation by questioning a representative sample of the appropriate population” (Neuman 2003, p. 267). The survey method involves a questionnaire or interview, and the data is either qualitative or quantitative. The survey allows researchers to think about alternative explanations, measure these explanations and then statistically examine their affects to rule out alternative explanations (Neuman, 2003). However, this approach is not appropriate considering this research, due to its inability in capturing reality under observation. Therefore, it would not be useful in gathering exploratory data.
On the other hand, a case study is an empirical study that “..investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (Neuman 2003, p. 33). In information systems, it is the process of studying participants in their natural setting at an organisational level. However, it has low control over alternative explanations, are conducted at a more organisational level, and not specifically focused on individuals. In addition individually analysis of employee data can become hard to analyse. Therefore, the organisational context is not appropriate for this research.

In contrast, an experiment can simply be defined as “modifying something in a situation, then comparing an outcome to what existed without the modification.”(Neuman 2003, p. 237). The experiment provides the researcher with the ability “..to find the causal relationships between selected variables in an environment which controls for alternative explanations” (Shanks et al 1993, p. 9). The major advantages of an experiment approach are that it’s easier to organize and can be repeated. The disadvantages include the difficulty in attributing outcomes to variable changes. However, an experiment allows for the observation of individuals in a controlled environment, controls alternative explanations, produces relationships between variables, and can explain causal affects. Therefore, the observation method of an experiment approach is ideal for collecting data on exploratory behaviour of users in the web context. The two dependent variables under consideration are the structured and unstructured environments and the application of exploration in each. Furthermore, the controlled environment allows for consistent observation techniques throughout the period of data collection.

### 3.3 Research Methods

A triangulation of methods was required to gather exploratory behaviour and navigational page data. The triangulation approach is the process of using multiple methods of research to provide a more comprehensive study by bringing together complementary
strengths of each (Neuman, 2003). The experiment consisted of observations and open interviews.

### 3.3.1 Observations

The observation enables researchers to obtain participant actions in a specific environment, natural or artificial. In the case of this research, the observations will be conducted in an artificial setting. The data collected from observations allow the researcher to redefine and create new concepts. (Neuman, 2003). In this research, concepts were developed and tested from observing exploratory behaviour, and used in the development of the exploratory task model.

### 3.3.2 Face-to-Face Interviews

Face-to-face interviews provide the ability to capture the surroundings, and use of nonverbal communication and visual aids of participants. However, disadvantages of the interview include interviewer bias on questions being asked and responses made (Neuman, 2003). Nevertheless, it allows a well-trained interviewer the ability to ask all types of questions with the use of probing.

### 3.4 Participant Sample

Participants of the experiment were gathered from the department of information systems and computer science. The technical aptitude of participants would have had an impact on the collected data, therefore obtaining participants from information technology related fields provided an assurance that they would have a high level of internet usage, an understanding of computer systems and applications, and a general interest in web based technology. This provided richer data collection, and thus reducing irrelevant data obtained from their inability to use web applications effectively. However, the participants web knowledge and usage was not a measured variable in this research.
The experiment consisted of a sample size of nine participants, who voluntarily offered their time. However, the initial sample size was twelve, and was considered a reasonably sample size based on the experimental design of observing two sites with multiple tasks. Although during the experiment period the participant number was not a problem, as data collected had reached saturation. Therefore, obtaining extra three participants was not necessary.

### 3.5 Research Method Application

The observations and interviews of participants provided data specific to each of the subsidiary questions:

- The literature review, observations and interviews provide an understanding of exploratory behaviour and provided the answer to subsidiary question 1 (presented in 3.1). This lead to the creation of an exploratory criteria.

- The criteria was then used to create the new exploratory task model (DIANE<sup>ne</sup>) and provided the answer to subsidiary question 2 (presented in 3.1). Navigational page data obtained from the observations was used in an analytical evaluation of the model’s capabilities.

### 3.6 Data Collection

The experiment involved participants exploring two web sites, each classified as either a structured or unstructured environment. Both environment selections were based on concepts discussed in the reviewed literature (Chapter 2).

The structured site had information/organisational based content, hierarchical site structure, and was content rich. Furthermore, the structured environment was familiar to
the participant providing distinctive signs (hyperlink headings, page titles etc…) and layout as typically seen from information/organisational sites. The structured site chosen was British Telecommunications (BT.com – screenshots Appendix A-2).

The unstructured site was required to provide unfamiliarity to the participant, using inconsistent features, and structure. A graphics design site, ProjectMiso, was chosen as the unstructured site (ProjectMiso.net – screenshots Appendix A-2), it used flash technology as the technology platform.

The choice of the sites considered the probability of participants being familiar with them, and therefore sites produced outside of Australia were considered. Furthermore, due to the nature of exploration, a large site structure was required to gather in depth exploratory data for later analysis. The differences in environments provided rich data in understanding exploratory behaviour in the web context.

The participants were asked to complete two tasks for each site (see Appendix A-1 for task descriptions), including a five-minute exploration stage before the tasks began. The exploration stage allowed participants to become familiar with the sites structure, navigation aids, and the capturing of exploratory behaviour without a defined task. After the completion of the exploration stage, participants were given their first task scenario. They were provided a description of a feature that existed within the site, with the goal to find the feature’s page. A detailed description was given, using specific keywords related to the sections and navigation aids of the web site. The second task was less detailed, focusing on a specific service/product name as the goal. The difference in task description provided deeper exploration, and detailed exploratory data.

In addition to observing participant exploration, interviews were performed during and after the completion of the experiment. Throughout the observation the researcher asked open interview questions. The questions were generally based on why a participant used a browser navigation button, why he/she selected a hyperlink (navigation aid), and the thought process during the exploration, to obtain general feedback on tasks set. After the
completion of the observation, participants were asked several questions on aspects of their exploration and the sites observed. The resulting interview answers provided a connection between what was observed, and the navigational page data retrieved.

Throughout the observation the researcher and participant’s voice were recorded. Furthermore, the participants computer screen was recorded in sync with the voices, capturing navigational page data, in terms of the hyperlinks clicked on, cursor movement, and pages loaded.

3.7 Data Analysis

The experimental data obtained from the experimental approach was placed through the following data analysis steps:

1. The observation data and participant responses were collated in separate transcript spreadsheets for each environment (see Appendix B).

2. The navigational page data recorded from the computer screen was used to analyse data on navigation aids selected, and the corresponding pages that were loaded. Each navigation aid was given a specific code relating to the navigational section it belonged to (see Appendix B). A navigational map of each section was drawn up beforehand with the corresponding codes for each link. Browser component interaction was also observed and recorded according to the component name. This process decreased confusion between links of the same name in different sections, and was thought of as an easier method of testing and identifying hyperlink interaction in the exploratory task model later on. The navigational page data was placed alongside the participants observation data and responses.
3. The gathered participant observations and response transcripts were analysed using a selective coding technique. The coding of data requires the researcher to organise raw data into conceptual categories, creating themes, which are used to analyse data (Neuman 2003). There is the existence of three coding methods that researchers use, although only selective was necessary in this research. The reviewed literature provided an extensive amount of research into exploratory behaviour and navigating methods, therefore the selective coding technique emphasised the existence of the aspects reviewed in the web context.

- **Selective coding** is the final pass of the three coding techniques. The researcher looks for cases that illustrate themes and make comparisons and contrasts.

The concepts reviewed in navigating methods and exploratory behaviour, in both application and game based systems were analysed against the observed exploratory behaviour. The selective coding was used to illustrated themes (see Appendix C) of similarities and potential differences, which were collated and then used for the development of the exploratory criteria.

4. The exploratory criteria was used in designing the operations, and the creation of the final DIANE\textsuperscript{nx} formalism. Each element of the criteria indicated a common aspect of exploratory behaviour observed during participant exploration, and therefore was required to be modelled.

5. The final step of data analysis involved an analytical evaluation of DIANE\textsuperscript{nx}'s formalism. The analytical evaluation involves a similar approach to a typical usability inspection method, although with some slight differences. Nielsen (1994) advocates that a usability inspection is a generic name for a set of methods that are all based on having evaluators inspect a user interface, using a set of heuristics or defined rules. They are aimed at finding usability problems at the design stage, though some address severity of usability problems, and the overall usability of a system. The analytical evaluation used the defined DIANE\textsuperscript{nx}
formalism to evaluate (inspected) its capabilities of representing exploration, using the collected page navigational data. This allowed the researcher to analyse any potential modelling (usability) problems and improvements within DIANE\textsuperscript{nx}.

Fig. 3.01 is a diagrammatic representation of the data collection and data analysis steps of this research.
3.8 Conclusion

This chapter discussed the development of the two subsidiary questions that form the research question. The research design was presented, which included the conduction of an experimental research approach, with the use of observations and face-to-face interviews as research methods. Page navigation data, observed aspects of exploration, and interview transcripts are used in the analysis.
answers formed the data collection. The data collection techniques were presented, which included a selective coding technique used in the analysis of interview and observation data forming the exploratory criteria. The criteria was used in the development of the exploratory task model. Furthermore, an analytical evaluation of DIANE's capabilities was performed using the navigational page data collected. In Chapter 4, the empirical findings on exploratory behaviour are presented, from the selective coding technique of interview and observation data.
Chapter 4
EMPIRICAL FINDINGS

The empirical findings of the experimental approach are discussed in this chapter. The findings were obtained from the data analysis (discussed in 3.7) of interview and observation data (see Appendix C). Several key aspects of exploratory behaviour were identified. The findings were based on two forms: The first form was identified from participant feedback, which provided a substantial amount of information on participant behaviour primarily based around their thought process; why a navigation aid was selected and generally comments on the site and exploration. The second form was primarily obtained from observations of participant’s navigation, which could not be identified from participant feedback.

4.1 General Exploratory Behaviour

This section presents the form of exploratory behaviour primarily obtained from participant feedback, expressed as general exploratory behaviour. The findings have been identified into four themes: semantic matching, task formation (exploration stage of the experiment), page aesthetics, and frustration.

Table 4.01 summarises the general exploratory behaviour observed.
### 4.1.1 Semantic Matching

Participants constantly scanned content for semantic matching of task description keywords.

**Structured Environment**

It was observed that participants scanned the content of a page before observing the main navigation of the website. They also examined main headings or hyperlink enabled headings before attempting to read the text under each, or within the page content. All participants semantically matched the keywords from the task description with those that were related in the headings. As described by participant 9, “basically when I go into a...
site I will look at the headings and then translate myself”, this type of feedback was evident from a majority of users, and could be observed by watching mouse movement (e.g. mouse glides over headings).

Furthermore, several participants indicated that they would read the text from the page content “only if it had anything relevant” (participant 2) to the task description. Or they could not understand the headings meaning, and therefore believed it was relevant and important to read the underlining text. In contrast, two participants read the entire text on each page without scanning, although the added artificial environment caused them to slower their pace during exploration, therefore enforcing this approach.

Only one participant indicated that the text under headings made the page look confronting to the eye, clearly displaying a sign of frustration whilst scanning. “This is quite confusing, words everywhere and jumbled” (participant 9).

Unstructured Environment
During the exploration of the unstructured site, participants did use semantic matching as a method of navigating both in exploration and task stages. However, it was observed in the exploration stage that participants were interested in the animation aspect of the site, therefore they were more inclined to randomly select navigational aids to observe what they loaded, before taking notice of the labels that appeared and their relation to the defined task.

Moreover, labels that appeared on mouse over (due to flash animation) of navigation aids and the content of the site, were primarily used to identify a semantic match throughout the task completion. In some cases the labels on navigation aids were written downward (90 degrees), this did not add as a deterrent for participants, some were even inclined to move their heads to the side to read them.

4.1.2 Task Formation
Participants formed their own tasks during the exploration stage.

**Structured Environment**

Participants were not given a task during exploration stage, however it was observed participants generally formed their own tasks from the home page. The formation of these tasks were based on several interests; personal (e.g broadband), stood out on the page itself (e.g colours, images, or sectioning), or the topic of interest was currently in the media. During the exploration several participants developed multiple tasks. These tasks resulted from the completion, or were the result of a deviation from the initial task. Majority of users on completion of a task, either went back to the home page to form a new task, or created a new one from where the left off. Although several participants indicated that they had not developed an interest and therefore decided to click on anything after the completion of the first set task. This was generally the result of no interest in the sites content, “I don’t know where to go ’cause nothing appeals to me”, as explained by participant 3.

In addition, it was observed several participants used the site-map as a task; they looked through the features of the site, viewing ones that they formed an interest with. This was seen as a form of discovery, and in all cases the participant did explore deeper into a feature of interest, the exploration was a quick process throughout the site map.

However, it was interesting to observe that one participant used the search facility constantly throughout the exploration stage, using several keywords to construct results that formed a possible task or developed an interest.

**Unstructured Environment**

The task question that constantly appeared in the exploration stage was “(I) Would like to know what this site is about?”(participant 6). It was interesting to observe that participants deviated from this task, and in most cases were amazed by the animation of the site and the interesting navigation aid representations. Furthermore, participants that
indicated they knew the answer to the task question quite early did require reassurance by observing all aspects of the sites features.

4.1.3 Page aesthetics

Page content sections and aesthetics enforced exploratory behaviour.

**Structured Environment**

Participants were asked on several occasions if content sectioning and other aesthetic aspects of the sites pages caused any effect on their exploratory behaviour. A majority of users indicated the boxed sectioning that existed on the site, provided a way of quickly scanning related headings in that section. However, they insisted that images and colours did not have an effect on their selection of navigational aids. Large sections related to a particular product or information were seen by participants first on viewing a page, but were generally not selected unless there was an interest to do so.

One participant pointed out the use of numbers and letters within an image helped identify the related heading or section on the page. For example, an image with the numbers 24/7’ provided a relation to the heading ‘24/7 customer service’.

Furthermore, another participant indicated that advertisements on pages were blocked out on viewing the content of the page. “*Flashing, boxed images with foreground text I don’t look at – they are ads!*” (Participant 5)

**Unstructured Environment**

It was observed that the aesthetics and animation on the site enforced a majority of the exploration in the exploration stage. Participants became interested with the animation and observed the affect mouse movement (animation had mouse sensitivity) had on it. Two participants indicated the colour of the navigation aids were remembered whilst exploring to sections within the site. On the other hand, others indicated the position of the navigation was remembered.
4.1.4 Frustration

Participants experienced frustration and became stuck during exploration.

Structured Environment
If participants become frustrated or stuck with their exploration, they generally changed their task, or ended the exploration all together. It was evident in the exploration stage that participants became frustrated when they could not develop a task, and therefore did not know where to navigate. A majority of participants ended up proceeding to develop a task based on a heading within the home page, or as one participant insisted they had enough of exploring and therefore ended the exploration stage.

However, during the task stages participants rarely became stuck or frustrated. Here they had the option of searching for the tasks answer from a task description. They seemed more confident in navigating to different sections of the site, or tracing back on navigational steps already taken.

Furthermore, several participants did mention once they became annoyed or frustrated with a site, they would leave instantly.

Unstructured Environment
There appeared to be a great level of frustration during the exploration stage of this environment. Several aspects of the site had caused this level of frustration; animation movement, usability and speed.

The animation moved constantly throughout the site, including the navigation aids. Comments such as “I hate when things move without clicking – I like to predict what will happen” (participant 1), indicated prediction was a major component of exploration and could not entirely exist in this environment, therefore causing confusion and frustration.
In addition, this made the usability of the site quite low, with participants using constant mouse movement to understand and relate to its purpose. However one participant indicated the animation was interesting and useful, but not for constant users. “*This sort of animation can be pretty annoying after a while for constant users*” (participant 2).

In spite of these frustrations, it appeared the animation provided an interest to keep on exploring once the task was complete, even if the participant became stuck from establishing the task goal.

4.2 Navigating Exploratory Behaviour

The following findings have been identified from primarily observing participant exploration, and the use of navigational page data. Therefore, the themes are based upon navigation. They include backward and forward tracking process, search facility use, and navigational aids use.

Table 4.02 summarises the navigating exploratory behaviour observed.
### Table 4.02 Navigating Exploratory Behaviour Findings

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Structured Environment</th>
<th>Unstructured Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backward and Forward Tracking Process</td>
<td>- Constantly used the back and forward browser buttons to load a previously visited page.</td>
<td>- Back and forward buttons were not used.</td>
</tr>
<tr>
<td></td>
<td>- Navigating through the site was generally a forward tracking process.</td>
<td>- Forced to use navigational aids to go back and forth.</td>
</tr>
<tr>
<td></td>
<td>- Navigating back through the site indicated the backward tracking process.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Opening of new windows and closure.</td>
<td></td>
</tr>
<tr>
<td>Search Facility</td>
<td>- Used as a last resort.</td>
<td>- Not provided.</td>
</tr>
<tr>
<td>Navigational Aids</td>
<td>- Stop button was not pressed.</td>
<td>- Stop button was not pressed.</td>
</tr>
<tr>
<td></td>
<td>- History and bookmark browser aids not used.</td>
<td>- History and bookmark browser aids not used.</td>
</tr>
<tr>
<td></td>
<td>- Use of back and forward button, and content navigational aids</td>
<td>- Use of content navigational aids</td>
</tr>
</tbody>
</table>

### 4.2.1 Backward and Forward tracking process

Participant performed constant back and forward process of visiting previously viewed pages.

**Structured Environment**

Throughout both the exploration and task stages, participants constantly used the back and forward browser buttons to load a previously visited page. The back button was used more often then its forward counterpart. Participant observations indicated the use of the back button occurred when the information they were looking for, or a change in task formation, resulted in a change of the page they were currently on. The resulting page from the use of the back button, either was a distinctive starting point of a broad range of topics for that particular sub-section of the site, or a particular hyperlink or heading was
remembered by the participant that provided some relation to the task at hand. The forward button, however, was generally used when the back button was initiated by mistake, or the resulting page from going backwards did not have any relevance for the task, and therefore the user insisted on exploring deeper into the sites navigation hoping to find relevant information.

In addition, the back and forward process was evident from the use of page navigation. Instead of using the browser buttons, two participants used the navigation provided on the page to go back and forward to previously visited pages. Although the participants indicated that this approach was used because they had navigated using the proper menu structured navigation bar on the pages, and this structure existed throughout the entire site. They were therefore comfortable in remembering navigation aid names and locations in the navigational bar.

Furthermore, several participants opened new windows with the selected hyperlink (from the background window) loaded as the displayed page. The new window, generally represented a sub-section (e.g. Broadband information) of the site, where the participant navigated a number of pages within the new window until they could not find the relevant information, or they came upon a new sub-section (e.g. Home phone information) of the site. Once this occurred, they would then minimise or close the opened window, going back to the original (background) window.

One participant interestingly opened many windows from the background page, navigating through each, minimising and opening several windows as he explored. The participant indicated there was no logical reason for doing this. It did appear to display confusion amongst the participant. Furthermore, on several occasions participants repeated their navigational path through pages previously visited sequentially, starting and finishing at distinctive remembered pages.
Unstructured Environment

Due to the nature of the site and the technology used (flash) the back and forward buttons did not exist. Therefore, participants were forced to use only the navigation aids provided on the site. The unfamiliarity of the navigational animation and colours used to represent each was overwhelming to several participants, participant 5 questioning, “Where do I click?” The site had a two level structure, for example navigating out to a page from the home page was the deepest level, you were required to navigate back to access the key sections of the site. However, there were sections within each page that opened either a window or animation component, thus making the site appear to have more levels in structure. Several participants were confused on how to return (close) to the original state once these sections were selected. Furthermore, the process of going back to the home page was represented by a coloured bar (with no label – unless the mouse hovered over it for a period of time it appeared). A majority of participants at first did not understand this concept, and the familiarity to the navigation on the home page. This indicated the back feature it provided.

4.2.2 Search facility

Participants used the search facility as a last resort in completing the task stages.

Structured Environment

In both tasks participants used the search facility as a last resort. It was generally used when they had explored the site to identify the task page though were unsuccessful in their approach. It was interesting to observe the range of keywords each participant who used the search facility entered. Some participants used a single keyword to sum up the task description, indicating that site search facilities generally do not work properly with multiple keywords, even though they had a searchable product name in the task description.

All participants in task two of the task stage used the search facility, this may have been from the deliberate difficulty in finding the task’s page. Three participants in both tasks
resorted to searching for the product from the start of their exploration, participant 4 indicating “(I) search when I don’t know what it is I’m looking for”.

In contrast, two participants indicated they would use google.com to place a domain search, participant 1 adding, “In my experience quick search does not provide me what I want”.

**Unstructured Environment**
The unstructured site did not provide a search facility, and participants did not ask or explore for the search facility.

### 4.2.3 Navigational Aids

Participants used a variety of navigational aids.

**Structured Environment**
It was observed that participants constantly used content hyperlinks or menu items in navigational sections on the page to explore. The back and forward buttons were used from the browser’s components. The history list and bookmark components were not considered during exploration. Furthermore, it was interesting to observe that participants did not press the stop button if they believed they had loaded an incorrect page, instead they pressed back.

**Unstructured Environment**
Due to the design of the unstructured environment, the flash animation did not allow the use of browser components during exploration. The hyperlinks that existed through the animation were used to explore.

### 4.3 Conclusion
The findings presented in this chapter discuss themes of exploratory behaviour obtained from the experimental research approach. The findings were presented in two categories: general exploratory behaviour, identified from participant feedback, and navigating exploratory behaviour, identified primarily from observing. The findings identified differences and similarities in the structured and unstructured environment. In Chapter 5, the navigating exploratory behaviour findings are discussed, and their use in the development of the exploratory criteria and DIANE\textsuperscript{rx} formalism. Furthermore, a discussion on why the general exploratory behaviour findings were not used in the exploratory criteria development is presented (discussed in 5.1). However, a more detailed discussion on the general exploratory behaviour findings, and an overview of the navigating exploratory behaviour findings is presented in Chapter 8.
Chapter 5

DIANE\textsuperscript{NX}: THE EXPLORATORY TASK MODEL

This chapter outlines the development of the exploratory criteria along with DIANE+’s inability for modelling task exploration. The two-phase modelling process is introduced, and its ability to enhance the DIANE\textsuperscript{NX} formalism. Finally, it discusses the creation of operations in the DIANE\textsuperscript{NX} formalism, and the extension of existing.

5.1 The Exploratory Criteria

The development of the exploratory criteria focused on the navigating exploratory behaviour findings. These findings involved the use of navigation aids during exploration. The general exploratory behaviour findings however, were not considered in the development of the exploratory criteria, as they focused on feedback obtained from participants, and could not adequately be applied within a task model formalism. Furthermore, these findings provide an understanding of why specific navigational aids were selected, and require the designer to observe and ask users questions to obtain specific details on exploration.

In addition, the empirical findings provided no differences in the use of navigational aids in both the structured and unstructured environments, except for the availability of aids (e.g. back & forward browser components were not present in the unstructured environment) Therefore, the exploratory criteria will take into consideration both environments.

Fig. 5.01 is a visual representation of the exploratory criteria, and the relations to each element.
The exploratory criteria was formed from three main elements: navigation aid elements, the use of navigation aids for exploring which provide the use of the exploration process elements, (include forward and backward tracking process), which then identify navigating method elements, as discussed in the review literature (Chapter 2).

Each element is discussed below:
5.1.1 Exploration Process Elements
The analysis of the navigating exploratory behaviour findings (presented in 4.2), indicated the existence of two main processes that participants engaged in whilst exploring: forward tracking, and backward tracking process.

Forward tracking process
The backward and forward tracking process findings (presented in 4.2.1), indicated the forward movement of exploring from one page to another. It was the process of exploring through the site uncovering pages down the hierarchy of the sites structure. This was provided through the selection of navigation aids, such as text hyperlinks, image hyperlinks, and the use of the browser components, forward button, enabled from the use of the back button.

Backward tracking process
After navigating through a series of pages, participants in most cases decided to navigate back to previous visited pages. The process of navigating backwards through pages previously visited was generally achieved by using the browsers back button. However, the use of a navigation aids were selected on several occasions (presented in 4.2.1).

5.1.2 Navigating Method Elements
The above processes and the facilitation of navigating aids provided an indication of where a navigating method was used or formed, and are a critical element of the criteria.

Landmark element
It was observed the process of using the forward and backward tracking element to a specific page indicated the participant was using the page as a hub within the task, or remembered an aspect of the page. This process indicated a landmark page. As discussed in the reviewed literature, Boling (2003) defined a landmark an identifiable feature within a landscape, and its use as a base for navigating out from and back.
A landmark page was distinguished by the usage of the following navigation aids:

*Back button* - Navigating backwards to the landmark page (backward tracking).

*Forward buttons* - The process of navigating out from the landmark page (forward tracking).

*Hyperlinks* - Used in providing a backward and forward tracking process for identifying landmark pages.

In addition, the use of a opening a new secondary window followed by the closure, after the participant had navigated through several pages, or viewed the single opened page, was seen as a forward and back tracking process. This identified the page in the original window as a landmark page.

**Route element**

Boling (2003) and Whitaker (1997) defined a route as a logical set of links that provided a path between pages. The route process was evident during the back and forward process findings. It was observed the repeat of navigational paths between pages, sequentially, were developed. These pages formed the logical set of links that form a path. Moreover, it was observed that the starting and ending pages of a route were landmark pages. A path was considered a route if it were taken at least twice during the exploration.

**Map element**

The use of the map/spatial orientation method for navigating was not evident in the findings. However, this is possibly due to the difficulties in observing a participant’s spatial orientation during exploration without requiring feedback on the process. Furthermore, as discussed by Whitaker (1997), the site map was used consistently throughout exploration. Although its usage does not indicate that a participant gathered specific spatial knowledge on the site under exploration. Nevertheless, it was considered that the entire exploration process performed by the participants represented their spatial orientation, and therefore a map of the sub-section in the site explored.
**Search element**

The facilitation of the search facility (presented in 4.2.2) provided participants with the capabilities of obtaining specific pages without the use of the preceding methods. The use of a search facility was classified by Whitaker (1997), as a navigating method in the web context. However, the search method is initiated by the use of entering keywords and the selection of a navigation aid (e.g. Search button), unlike the preceding elements, which require the combination of back and forward tracking process. The use of a site's search facilities provides the user with a powerful navigational method during exploration and will be considered as part of the criteria in modelling exploration.

### 5.1.3 Navigation aid elements

The elements of the criteria are identifiable from the selection of navigational aids. These navigational aids exist in two categories; browser (back & forward buttons, bookmarks, history list) and the page content (text & image hyperlinks, breadcrumbs, main navigational sections). Furthermore, it was observed that the page content navigation aids were used before the main navigational sections.

### 5.2 DIANE+ Exploratory Modelling Evaluation

DIANE+’s existing task model formalism was analysed against the exploratory criteria. This indicated where DIANE+ lacked in its ability to model task exploration. The criteria were then used to develop new operations to enhance its representation of exploration.

The following discussions and diagrams indicate where DIANE+ lacks the ability in modelling task exploration according to the exploratory criteria.

#### 5.2.1 Forward & Backward Tracking
Navigating through pages is a sequential process; it is only one task. The following issues arose when modelling forward and backward navigation:

- Linear representation: large navigational tasks will produce a long linear model. (fig. 5.02)
- Page and navigation aid repetition: previously visited pages and the selection of navigation aids are represented more than once. (fig. 5.03)

The selection of a navigation aid and the resulting page loaded, are represented by the interaction and automatic operations of the DIANE+ formalism (see Appendix D-2).

Fig. 5.02 DIANE+ Sequential representation.
Fig. 5.03 DIANE+ Page and navigation aid repetition.
It can be seen from these diagrams that modelling exploration is concerned with modelling sequential actions of the users exploration. However, DIANE+ can model this sequential action quite significantly, though the formalisms and processes available for representation are not adequate in the context of exploration. Therefore, the development of the exploratory model concentrated on the sequential flow and enhancements of the existing formalism, considering the visual perspective of existing operations, and extending the meaning in representing the criteria.

5.2.2 Landmark Representation

A landmark (discussed in 5.1.2) was developed from the repeated use of a forward and backward tracking process from and to the landmark page. As discussed above, forward and backward tracking were not represented clearly using DIANE+, and the representation of previously visited pages does not indicate the existence of a landmark. The following diagram (fig. 5.04) displays the forward and backtracking process, indicating a page landmark.
Furthermore, there is no distinctive operation or process indicating the opening and closing of new browser windows (discussed in 5.1.2). Although this process can be modelled using an existing operation it creates difficulty in visually identifying where there is an instance of a new window, and the closure of a window.
### 5.2.3 Navigation Aid Representation

The representation of selecting a navigation aid can be enhanced in regards to modelling exploration within a website. An enhancement in the formalism to represent different types of navigational aids or the use of navigation aid sections (discussed 5.1.3) was required. This would benefit the designer in visually identifying aid names, and main navigation aid section use.

### 5.2.4 Route Representation

Visually a route is not clearly defined using the DIANE+ formalism. A grouping operation was required to diminish the repetition of route pages, enhancing DIANE+’s sequential modelling of a user’s exploration.

### 5.3 Two-Phase Modelling Process

In addition to the exploratory criteria and its use in the development of the DIANE\textsuperscript{nx} formalism, a two-phase modelling process was developed to enhance the developed models representation of exploration. As discussed in the literature review (Chapter 2), a task model is concerned with representing the tasks needed to complete a specified goal. It was observed in the empirical observation that participants created their own tasks on many occasions to provide a purpose for the exploration stage (presented in 4.1.2), although it was unclear from the collected navigational page data, where participants defined new tasks, unless they were asked specific questions on task formation whilst exploring. Therefore, the development of the model and the context of its use, were focused on the task exploration stages, fitting with the defined usage of a task model.

The process of using the exploratory task model can be split into two phases. The two-phases approach focuses on providing the designer with a powerful method of understanding the exploration of single users, and the primary deviations of multiple
users formed using the exploratory task model. The two phases are: individual exploration and deviation consolidation, taken from a concept addressed by Beyer (1997), using one representation of a system design for user needs.

**Phase 1: Individual Exploration**
The individual exploration phase models a single user’s task exploration using the exploratory task model. This provides the designer with the ability of capturing multiple models of the same task, each performed by individual users. Therefore, the designer can analyse the exploratory deviations from the intended task path, including the navigational aids selected, and the exploration behaviour applied.

**Phase 2: Deviation Consolidation**
This phase consolidates all exploratory deviations from the designers intended task path. The intended task path includes the correct site pages that are required to be loaded in retrieving the task’s page. The deviations from each intended page within the task are consolidated from each user in phase one. This provides the designer with a powerful tool in understanding where, and possibly why the deviations were made. The modelling approach taken in this phase includes the representation of the designers intended pages required to complete the task, and extensions on each displaying where the common deviations occurred in phase one models.

An example of the two-phase process is given in chapter 6.

**5.4 DIANE\textsuperscript{nx}: The Exploratory Task Model**

This section outlines and discusses the creation of DIANE\textsuperscript{nx} (\textsuperscript{nx} = navigational exploration) formalism.
5.4.1 Formalism Development

The development of each operation was based on the exploratory criteria and DIANE+’s sequential inability to model exploration adequately. There are two forms of operations that were used in the development of the DIANE\textsuperscript{nx} formalism:

1. The original operation – obtained from DIANE+. It provides the ability to model an element in the criteria, therefore to change its representation or meaning is not required. The relation of each operation in representing an element of the criteria is discussed in Appendix D-2.

2. The new operation. These operations were either built from an existing DIANE+ operation, which provided partial meaning for the appropriate element in the criteria, therefore an added representation provided a more detailed meaning for representing the element. Or an element in the criteria was inadequately represented using a DIANE+ operation, therefore a completely new operation was developed.

Throughout this section a discussion on each newly created DIANE\textsuperscript{nx} operation is presented, including description, and usage rules. To provide a clearer understanding of the processes required in applying the developed formalism, a task scenario walkthrough of the formalism is presented in chapter 6 (along with the two-phase modelling process). This chapter discusses scenario applications based on the analytical evaluation of each operation, and displays innovations that exist in DIANE\textsuperscript{nx} in modelling task exploration.

The operations from the DIANE+ formalism that were not required in modelling task exploration, and why, are presented in Appendix D-1. Furthermore, phase two of the modelling process, deviation consolidation, requires operations that exist from the original DIANE+ formalism. This is discussed in Appendix D-2, and the application presented in Chapter 6.
5.4.2 New Operation Development

This section discusses the new operations developed for the DIANE\textsuperscript{nx} formalism. Usage examples are given for each, providing a visual understanding of each usage rule. Furthermore, where required, the usage rules may reference original DIANE+ operations in Appendix D-2, for the appropriate application of operations.
5.4.2.1 Page Interaction Operation

*Exploration modelling description:*

It was discovered while modelling task exploration, and during the observation (discussed in 3.7) that the amount of navigational aids available for users to select (especially in a typical structured environment) and the multiple aids that navigated to the same page, meant the designer would find it quite difficult to produce a visual of the location of each navigational aid selected. Therefore, the interaction operation has been extended to provide designers the ability to indicate the section and location of the navigation aid (discussed in 5.1.3) selected.

(usage rule numbers correspond to usage example figures).

**Usage Examples:**

1. Applied before an automatic (see Appendix D-2) or landmark operation (discussed further on in 5.4.2.2).

*<navigational aid>*. The name of the navigation aid selected by the user. This may also include the type of navigation aid (e.g text, image, bookmark, history list, breadcrumb).

*<section>*. The navigation sectioning in the page content where the aid is located. This may be represented in words (e.g Top Bar, Left Bar) or by a symbol indicating it’s position.
A code, which represents the position of the navigation aid in a section of the page content. This allows designers to quickly reference a selected navigation aid for further analysis of the model. The designer produces the code (e.g. ‘Corporate’ hyperlink, 2nd in the left navigation bar on the page).

5.4.2.2 Landmark [Automatic] Operation

Exploration modelling description:
Combined with the original automatic operation (see Appendix D-2), a triangle in the background indicates that the page loaded is a distinctive landmark. (discussed in 5.1.2).

The use of the existing automatic operation indicates the loading of a page that was not part of a backward or forward tracking process.

Usage Rules:
1. A landmark operation must follow a page interaction operation (presented in 5.4.2.1).
2. Placed before a backward (presented further on in 5.4.2.3) or forward operation (presented further on in 5.4.2.4), indicating the landmark representation.
3. Represented after the use of a page jump operation (presented further on in 5.4.2.5) to the landmark page.

<page name> The name of the page displayed.
5.4.2.3 Backward Operation

Exploration modelling description:

One major disadvantage that existed in DIANE+’s ability to model exploration was the repetition of automatic operations that indicated pages that had previously been visited (discussed in 5.2.1). Therefore, a grouping operation was needed to eradicate the redundancy of multiple appearances of the same page due to the backward and forward tracking process.

The backward tracking process (discussed in 5.1.1), feed the development of the backward operation. The majority of backward tracking through pages was initiated through the use of the browser’s back button. The use of going backwards using navigational aids present in the contents of the page were unique, and introduced complexity in the development and application of the operation. Therefore, they were not considered part of the backward operation, and are represented by the page jump operation (presented further on in 5.4.2.6).

The operation represents the exploratory behaviour of using the browser components, back button, and new window closure. It is applied as a container, whereby holding all operations that were explored forward from the page before the user explored back. This operation therefore indicates the existence of a landmark page (discussed in 5.1.2). Furthermore, a page interaction operation (presented in 5.4.2.1) follows the end of the backward operation.

Moreover, page interaction operations within a backward operation are ignored during the backward process, due to the back button
Usage Example

1. 

2. 

3. 

4. 

Addition Example

initiation.

Usage Rules:

1. Applied as a container around operations.

2. Must follow an automatic (see Appendix D-2) or landmark operation (presented in 5.4.2.2).

3. Page interaction operation (presented in 5.4.2.1) follows on from the end of the operation, and indicates the previous automatic or landmark operation was a landmark.

4. If several backward operations exist for the same page, they are represented inside each other. Smaller operations are initialised before the larger, unless there is a window opening within a backward, or a sequence arrow (see Appendix D-2) following a backward operation after the initiation of a forward operation (presented further on in 5.4.2.4) – the back operation before the arrow is initialised first.

Additions: New Window

To represent the action of opening a new window, and the closure to the background window (discussed in 5.1.2), a cross at the top right hand side of the operation indicates a new window operation.
5.4.2.4 Forward Operation

Exploration modelling description:
The forward operation was developed from the forward tracking element in the criteria (discussed in 5.1.1).

The operation captures the use of the forward browser button, and eradicates the modelling of multiple operations of a revisited page (5.2.2). The use of an operation visually enhances the sequential process of task exploration modelling.

Usage Rules:

1. The forward button is enabled after the back button has been used. Therefore, the forward operation can only be used within a backward operation.
2. The backward operation is initialised before the forward operation.
3. If the forward operation is modelled within a multiple backward operation, then the forward operation is performed after the surrounding backward operation.
5.4.2.5 Route Operation

Exploration modelling description:
A route indicates the iterative navigating between two landmarks, or repetition of page paths (discussed in 5.1.2). Therefore, to model this element of the criteria a route operation is applied around one iterative path of the route taken. An iterative operation is applied to the bottom right hand corner of the route operation, indicating the number of times the route (path) was taken between landmark, or automatic operations.

This operation is not applied to routes that use different page interaction operations for the loading of the same page (automatic operation), the page jump operation (presented further on in 5.4.2.6) is used in this instance.

Usage Rules:
1. Apply around existing operations.
2. The route must been taken at least twice to become a route.
3. Iterative operation number (Appendix D-2) applied at the bottom right hand corner, indicating the number of times the route was taken.
4. Only model one instance of each page interaction or automatic operation used in the route.

To enhance the readability of the formalism, the following operations were developed partly on the exploratory criteria: page jump operation, section link, and sub-section operation.
5.4.2.6 Page Jump Operation

*Exploration modelling description:*

The page jump operation represents a page (automatic or landmark operation) that has previously been visited, but was not part of a sequential backward or forward operation.

As discussed in 5.4.2.3, the backward operation is used to represent the use of a back button, or new window opening and closure. The loading of a revisited page from the selection of a navigation aid is not represented by this operation. Therefore, the jump operation allows the designers to model the revisitation of pages within any stage of the user’s task exploration.

However, this operation is modelling page repetition which was indicated a fault of DIANE+’s formalism. Although its representation visually enhances the models capabilities of clearly defining the revisitation of a page.

*Usage Rules:*

1. A page interaction operation is initialised before the page jump operation.
2. The page represented by the automatic or landmark operation must exist in the model.
3. A page interaction operation follows the page jump operation, unless within a backward or forward operation, or the end of the task.

*Additional Usage:*

Distinguishing page names by the use of a code may make locating the previously visited page easier for the designer analysing the model.
5.4.2.7 Section Link

**Exploration modelling description:**
In addition to the page interaction operations (presented in 5.4.2.1) extended navigational aid details, the sectioning link is applied in the model when a navigation aid in the page content is selected from a different navigation section to the previous. For example, a user may navigate using the hyperlink menu within the left navigational aid section, after using the left menu for several pages they decide to navigate back to the home page by pressing the ‘home page’ hyperlink in the top menu section of the page. Therefore, this change of navigation aid sectioning use is indicated in the model by using the selection link.

There are several reasons why this method is required:

1. Due to the nature of modelling exploration, the model may become quite large. Therefore, this method helps reduce the models length and enhances its capabilities in modelling exploration.

2. By grouping the task model into the usage of navigation aid sections, allows the designer to analyse visually the extent in which each section was used.

The designer defines the navigation sections.

**Usage Rules:**

1. Applied between two page interaction operations, or backward and forward operations.

2. The automatic, backward or forward operations before the page interaction operation are modelled on the previously line. The section link indicates this connection.
5.4.2.8 Sub-Section Operation

*Exploration modelling description:*
Due to the nature of exploration the model may become quite large. Therefore, a sub-section operation was required, so when necessary the model could be split into several sections.

**Usage Examples:**

1. 

2. 

**Usage Rules:**

1. Applied at the end and start of the associated sections.
2. Numbers within the operation represent ordering of the sub-sections.

5.5 Conclusion

This chapter discussed the development of the exploratory criteria based on the navigating exploratory behaviour empirical findings. The two-phase modelling process was introduced, providing designers with the ability to extract individual exploration and consolidate deviations from multiple users. The sequential process of DIANE+’s task model formalism was evaluated indicating operations that were not required in modelling exploration, and operations that required extending. This lead to the discussion on the DIANE\textsuperscript{nx} task model formalism development based on the exploratory criteria, and the usage rules required for each operation for correctly modelling task exploration. In chapter 6, the developed DIANE\textsuperscript{nx} formalism and the two-phase modelling process are presented through a task scenario walkthrough obtained from the analytical evaluation of DIANE\textsuperscript{nx}. This provides a deeper understanding of how the operations of the formalism are applied and represented for task exploration.
Chapter 6
DIANE\textsuperscript{NX} TASK SCENARIO WALKTHROUGH

This chapter illustrates DIANE\textsuperscript{NX}’s use of modelling task exploration with a scenario walkthrough of one participant’s task exploration. This process was conducted with the observed participant navigational page data and was used in the analytical evaluation (discussed in 3.7) of DIANE\textsuperscript{NX} (other participant scenario walkthroughs can be found in Appendix E). This indicated the innovations of the developed formalism, and provided a clearer understanding of the processes required in applying the operations with the two-phase modelling process.

6.1 Phase 1: Individual Exploration

As discussed in section 5.3, Phase 1 of modelling task exploration consists of modelling a user’s individual exploration. By obtaining several user’s task exploration, the designer can then apply these models to Phase 2, and extract deviations from the intended task path.

The data used in the modelling process was obtained from the empirical experiment’s task one of the structured environment. An assumption was made on the intended page path of the task, and was created based on the main menu navigation structure. The resulting menu items that appeared after navigating through each page indicated the desired navigation path for locating the task page (see Appendix A-1 for detailed task description and intended page path).
6.1.1 Backward and Forward Operations Scenario

The following scenario steps through the modelling process of one particular participant constantly using the back and forward tracking process (discussed in 5.1.1). This scenario was chosen based on the common usage and importance of the backward and forward tracking process in participant task exploration.

The following two figures represent the participant’s exploration. Figure 6.01 models the participants exploration using DIANE+. Figure 6.02 models the participant’s exploration using DIANE\textsuperscript{nx}.
Legend of navigation sectioning codes (used in the page interaction operations in the DIANE\textsuperscript{nx} representation diagrams):

PH = Page Content Hyperlink
N1 = Left Navigation
N2 = Right Navigation

\begin{itemize}
\item \textcolor{red}{=} Indicates the repetition of pages
\item \textcolor{blue}{=} Indicates a page which belongs to the intended navigation task path.
\end{itemize}

Fig. 6.01 DIANE+ Scenario Representation
Fig. 6.02 DIA NE\textsuperscript{TM} Scenario Representation

DIANE\textsuperscript{TM} Formalism

Legend of navigation sectioning codes:

PH = Page Content Hyperlink
N1 = Left Navigation
N2 = Right Navigation

Legend of navigation sectioning codes:

PH = Page Content Hyperlink
N1 = Left Navigation
N2 = Right Navigation

Automatic Operation
Navigation Aid Selected
Interaction Operation
Page Loaded

Landmark Operation
Page Loaded is a Landmark

Backward Operation
Use of back button

Forward Operation
Use of forward button

Sub-section Operation
Breaks model into parts

Terminal Node
End of task

Sequence Link

Section Link
Use of different navigation sections
The circled numbers in figure 6.02 correspond to the section descriptions below.

**Section 1: Forward tracking within multiple back tracking operations.**

- **Smallest inner backward operation captures the following:**

  ![Diagram](image)

  After the loading of the “Search[It Solutions] page’ the participant selects the back button, which loads the previous ‘Site Map Page’. This is represented by the backward operation, which has been placed around both the automatic and interaction operations.

- **2nd smallest backward operation captures the following:**

  ![Diagram](image)

  The participant navigates out from the ‘Site Map page’ again, loading the ‘Search[Customer Service] page’, and then presses the back button. The outer backward operation indicates that the operations within were done second to the inner, both returning to the same page – representing a landmark operation.

- **Outer backward operation captures the following:**

  ![Diagram](image)

  As described in the formalism development (Chapter 5), the inner backward operations before the outer, indicate the operations within were done before the operations in the outer backward operation. In the two backward operations the participant pressed the back button to the ‘corporate page’.
Forward tracking operation captures the following:

The forward operation within a backward operation represents the selection of the forward button after the use of the back button. As discussed in section 5.1, a forward operation is not possible without the existence of the backward operation beforehand. The representation in this instance indicates the navigation from ‘Corporate Page’ to ‘Search[IT Solutions]’ was done after the outer backward operation.

Section 2: Backward operation following a forward operation.

Inner Backward operation captures the following:

From the forward operation, the participant loaded the ‘Search[Products] Page’, and then went back to the ‘Site Map Page’. The backward operation in which the forward operation is surrounded by, as described above, is done before this backward operation; the arrow indicates this.

Outer backward operation captures the following:

The outer backward operation indicates that after the inner backward operation, the participant went back to the ‘corporate page’.
6.2 Phase 2: Deviation Consolidation

The consolidation phase (discussed in 5.3), models (figure 6.03) deviations obtained from the participants in Appendix E, from pages in the designers intended task path. This is done by extracting the deviations from phase 1 models and consolidating them into one representation. There are three possible ways of extracting deviations:

1. Extract deviations from each page of the intended task path. The deviation ends when the next page in the task path was visited (represented in fig. 6.03).
2. Extract only the same deviations that occur in several users’ individual exploration models. This will provide designers with information on consistent deviation problems.
3. Extract to the first automatic (see Appendix D-2) or landmark operation (presented in 5.4.2.2) of the deviation path. Since this is where the deviation begins, issues resulting in these deviations are more than likely present here.

The following figure 6.03 represents the deviation consolidation model.
The indicated circled numbers in figure 6.03 are discussed in further detail below:

1. **Deviation sub-task representation**
   Each page is represented as a composite interaction operation (refer to Appendix D-2), the deviations are sub-tasks performed by the users.

2. **User deviation identification**
   To indicate individual user deviation, a number on the top left hand corner is placed indicating the user.

3. **Representing backward and then forward operations in deviations.**
   Since the page in which the deviation is occurring from is not represented with the deviation itself, the representation of backward followed by forward is not modelled correctly. Therefore these two processes are split into two separate deviations.

4. **The OR operator (see boolean operators Appendix D-2) represents multiple deviations from a page.**
   This provides a way of indicating multiple deviations from a page.

### 6.3 Conclusion

This chapter demonstrated the abilities and application of DIANE\textsuperscript{nx} formalism within a participant’s exploration scenario. The scenario was modelled using the two-phase modelling process. Phase two, deviation consolidation, was represented with the additional scenarios in Appendix E. Finally, a discussion on the deviation consolidation modelling process was illustrated. In Chapter 7, an overview of DIANE\textsuperscript{nx} and the two-phase modelling process is given. In addition a detailed discussion on the reviewed literature and the empirical findings is presented.
Chapter 7
DISCUSSION

This chapter outlines a discussion on the conducted research. The exploratory behaviour empirical findings are discussed and there relation to the reviewed literature into exploratory behaviour in application and game contexts. This is followed by an overview of the navigating exploration behaviour findings, and there use in the creation of the exploratory criteria. Finally, a general discussion on the developed DIANE\textsuperscript{nx} formalism is presented.

7.1 Exploratory Behaviour in the Web Context

The empirical findings presented several aspects of exploratory behaviour for both structured and unstructured environments. Furthermore, there was an indication of similarities among these environments in relation to exploratory behaviour in application and game-based systems. The discussion below outlines similarities and differences observed based on the key themes addressed in the empirical findings general exploratory behaviour (Chapter 4).

Task Formation

Structured Environment

Task formation in the exploration stage (presented in 4.1.2) provided interesting similarities to the reviewed computational systems. Participants in the structured environment formed their own tasks during exploration of the site. It was observed in most cases this exploration ended once the goal had been achieved, indicating a task was
required to enable exploration. Rieman (2003) and Waern (1987) observed this aspect of exploratory behaviour in application systems, advocating exploration is task-driven, users postpone exploration until given (or in this case created) a real-task. However it was observed in several instances that participants once having completed a task, engaged in random things to try, as discussed by Barton and Draper (1993). Although the random action was only initiated after a set task was achieved. However, this could potentially indicate a time factor may have caused this behaviour, participants waiting for the researcher to end the exploration stage, so they initiate a random action.

**Unstructured Environment**

The unstructured environment site (presented in 4.1.2) however, posed similarities to both the application and game-based systems, participants were observed starting with a defined task “(I) Would like to know what this site is about?”(Participant 6), and then ended up deviating from this task due to both the unfamiliarity of the sites structure and aesthetics. Therefore the defined task introduced similarities to application based systems (Rieman, 2003; Waern, 1987). However, participants were drawn in from the fascination and realistic navigational surroundings of the site producing similarities to game-based systems, discovering things with abstract task formation (Carroll, 1990), with the process of randomly trying navigation aids, observed by Barton and Draper (1993). Although it could be argued that the observed unstructured site, and its use of animation paved the way for this type of exploratory behaviour (task formation) due to its similarities to game based systems (Carroll, 1990), even though its structure was unfamiliar to participants.

**Frustration**

**Structured Environment**

In addition, frustration (presented in 4.1.4) during the structured environments exploration stage caused either the ending of a task, or the changing of an existing task. Barton & Draper (1993) and Rieman (1996) observed that this frustration is possibly caused by minor problems in the user interface, such as their inability to semantically match menu items with task descriptions. In this research this consisted of the matching
of navigation aid labels or content headings with task descriptions. Furthermore, frustration in some instances caused the participant to get stuck, which may have been the result of completing the defined task and therefore unsure of where to go. However, as discussed in the findings, participants rarely became stuck or frustrated during the task stages. This could be the result of having a defined task given to them by the researcher, and therefore confident in knowing the task page existed in the site. Moreover, the use of search facilities, once unsure of their direction, may have reduced their frustration and becoming stuck.

**Unstructured Environment**

On the other hand, in the unstructured environment, the unfamiliarity caused by the animation and site structure increased participant frustration. It was pointed out by several participants (presented in 4.1.4), that the use of animation and the unfamiliarity of the site decreased the usability of the site, therefore increasing frustration during exploration and task stages of the site.

**Semantic Matching**

A similarity that existed in both environments from all participants was the use of semantic matching (presented in 4.1.1) of headings or navigation aid labels with keywords in the task descriptions. In most cases this was the main process of exploration, where the text was not read unless the participant believed the headings above provided some relation to the task description.

**Page aesthetics**

**Structured Environment**

It was observed that page aesthetics (presented in 4.2.3) did not contribute very much to the participant’s exploratory behaviour. Several participants however did indicate the use of boxed sectioning within the structured site provided a way of quickly identifying sections of the content.
**Unstructured Environment**

Furthermore, it was interesting to observe that several participants within the unstructured environment remembered the positioning of navigation aids, due to the representation of colour, and not the labels that appeared after leaving the mouse over an aid for a period of time (presented in 4.2.3).

Overall, the formation of tasks within the exploration stage of the structured environment and the observed exploratory behaviour of participants, provided similarities to application based exploratory behaviour, and indicated its use as a work product (discussed in 2.2). This could be the result of the sites type and structure (informational/organisational site), and its general use in retrieving information about a particular product or service. It was also evident that in exploration stage, the aim of exploring was based on achieving a specific goal, not from randomly trying things.

The unstructured environment provided similarities to exploratory behaviour observed in game based systems, for both task formation and page aesthetics. This was possibly the result of the unfamiliarity in the sites structure and the use of animation (colours, movement, shapes etc) in representing navigation aids.

### 7.2 Navigating Methods Overview

In addition to the observed general exploratory behaviour (discussed above and presented in 4.1), the observed findings in navigating exploratory behaviour (presented in 4.2) indicated three distinctive processes, backward and forward tracking process, search facility use, and navigational aid use. These processes identified the usage and existence of four navigating methods, discussed in Chapter 2, during exploration. These methods formed the elements of the exploratory criteria and are discussed in more detail in Chapter 5. The methods included: landmark pages, route of pages, map of task exploration, and search facility use.
**Landmark** page – identified as a base, where users explored out in a direction of the site and then back again. Also known as the hub-spoke effect (Rosenfield & Morville 1998). The landmark page was generally remembered by a semantic match of keywords in the task description with headings or navigation aids on the page.

**Route** of pages – identified by the process of repeating navigation through an existing page path, distinguished by remembering landmark (start and end pages) and signs within pages (e.g. headings).

**Map** of task exploration – identified by the entire task exploration process. This was due to the inability of obtaining specific spatial orientation and knowledge of the participant exploration without the use of intensive questions and feedback from the participant. Therefore, it was seen as inadequate to represent a map method within DIANE\textsuperscript{nx} and was decided that it represented the exploration process as a whole.

**Search** facilities – identified by using the search page of a site. The search navigating method was advocated by Whitaker (1997) through the use of search facilities within a page.

Furthermore, the use of breadcrumb hyperlinks, browser history lists and bookmarks in forming the preceding methods of navigation were not considered by participants during exploration. The navigation aids used included (discussed in 4.2.3): browser back and forward buttons, and page content navigation aids (text hyperlinks, image hyperlinks, menu section hyperlinks).
7.3 DIANE\textsuperscript{nx} Formalism

The above navigating exploratory behaviour and the developed navigating methods, formed the elements of the exploratory criteria, which were used in the development of DIANE\textsuperscript{nx} formalism. Furthermore, the exploration performed by participants in the exploration stage did indicate several formations of tasks, although this formation was not evident without the necessary feedback from the participant under observation (discussed in 5.3). Therefore, the development of the DIANE\textsuperscript{nx} formalism considers the modelling of task exploration, which was obtained from the task exploration stages of the experiment. A task is clearly defined by the designer and fits the general definition and purpose of a task model.

The general exploratory behavioural findings provided results that could not be incorporated into the DIANE\textsuperscript{nx} formalism. Originally it was believed that the experiment would produce findings that indicated new processes and applications of exploratory behaviour in both environments. However, after analysing the findings it appeared that the behaviour aspects observed at this stage could not be applied in the context of task modelling, and could only be used in understanding why exploration and specific deviations occurred from the designers intended task path, which is not the focus of this research.

In spite of this, the behavioural aspects provided some interesting similarities to application and game-based systems, and furthermore obtained valuable exploration data for its use in the analytical evaluation of the DIANE\textsuperscript{nx} formalism (discussed in 3.7). Moreover, the derived understanding of these findings and the general process of participant exploration, enhanced the DIANE\textsuperscript{nx} formalism’s application and the two-phase modelling process by allowing the researcher to understand the context of exploration and the environment in which the DIANE\textsuperscript{nx} task model will cater for. This could not be gathered from a general evaluation and development based on the reviewed literature.
In addition to the DIANE\textsuperscript{nx} formalism, the two-phase modelling process was developed. This provides designers, at the evaluation stage of the user interface, with the ability of modelling multiple individual participants exploration with the same task, and then using the deviation consolidation method to extract deviations from the intended task pages for further analysis of participant exploration.

### 7.4 Conclusion

The general exploratory behaviour findings were discussed in their observed themes: task formation, frustration, semantic matching and page aesthetics enforced exploration. It was concluded that the structured environment posed similarities to the application context, and was generally used as a work product. The unstructured environment posed similarities to the game context, due to navigational aids, animation, and unfamiliarity of the site. Furthermore, the observed navigating exploratory behaviour findings provided the indication and usage of the four navigating methods reviewed in the literature (Chapter 2), identifying a landmark page, route of pages, exploration as a whole representing a map, and the use of a search facility. Both types of findings provided the answer to subsidiary question 1 (presented in 3.1). The navigating methods observed were used in the creation of the exploratory criteria, this lead to answering subsidiary question 2 (presented in 3.1). Finally, an overview of the DIANE\textsuperscript{nx} formalism was presented, including the two-phase modelling process. In Chapter 8, the limitations of this research based on the findings obtained are discussed. Furthermore, from this the recommendations of future research are presented and the final contributions of this research in the Information Systems community.
Chapter 8
CONCLUSION

This chapter discusses the limitations identified while conducting this research and with DIANE\textsuperscript{RX}. The recommendations for future research are suggested based on these limitations, and research findings. Finally, the contributions of this research are discussed, for the Information Systems (IS) community, for both practice and research.

8.1 Limitations of this Research & Model

The limitations of this research were identified and are as follows:

- As discussed in section 3.4, the amount of participants involved in the experiment provided data saturation and therefore the required amount of twelve (in which nine were observed) was not required. However, due to the tasks, websites observed, time restrictions, and the focus of this research, a larger sample of participants with a better structured analysis of websites and tasks in several sites classified as unstructured and structured could have provided greater detailed findings.

- The two sites observed were created by organizations outside the researchers control. The content, structure and layout of the sites observed were considered the best fit for the purpose of this research, considering unfamiliarity by the user and size for exploration. Due to the overseas nature of the sites, especially the structured, and terms used (such as currency) in some cases did cause participants to deviate from a particular page in their exploration. Sites built by the researcher could provide a better solution to this matter. However, considering the magnitude of this task, time did not allow this.
A better selection of the unstructured site to incorporate navigation based on hyperlinks in different locations throughout the content with no a clear structure. This may provide a better similarity to an unstructured environment as described in the reviewed literature.

The limitations of the DIANE\textsuperscript{nx} task model are as follows:

- The use of the backward and forward operations during modelling exploration can become quite confusing if the participant has selected the back and forward buttons multiple times. However, these operations are required to visually enhance the model according to web site exploration, and therefore any improvements may decrease this enhancement.

- The Phase 2, Deviation Consolidation of the two-phase modelling process, may introduce problems when extracting deviations from sections of Phase 1 that indicate the use of the backward operations with a section link (presented in 6.2). Splitting this representation into its deviation path may not represent the deviation correctly.

### 8.2 Recommendations for Future Research

Based on these limitations and other aspects identified during the research, the following recommendations are suggested for future research:

- To extend DIANE\textsuperscript{nx} to include a methodology for understanding how, and why task deviations occurred during a task, based on aspects of exploratory behaviour in the web context.

- A comparison of the structured and unstructured environment findings; in terms of exploration stage versus task stages.
- More detailed analysis of exploratory behaviour within several sites in both structured and unstructured environments, that contains different structures, layouts and page aesthetics with the use of different web technologies (e.g flash, java, E-Commerce systems etc…).

- To extend DIANE\textsuperscript{rx} formalism to incorporate other aspects of exploration, such as formalisms for general exploratory behavioural feedback from users (e.g task formation, semantic matching, identifying signs etc…). Furthermore, extending to allow for identifying pure exploration without guided tasks.

- A software tool development for modelling exploration using DIANE\textsuperscript{rx}

- An evaluation into the usability and readability of DIANE\textsuperscript{rx}’s operations, in comparison to the DIANE+ task model.

### 8.3 Contributions

This research has contributed to the IS research and IS practice communities in the following ways:

**IS Research Community:**

- It has provided a general overview of key aspects of user exploration in the web context, in both structured and unstructured environments. Furthermore, an overview of the similarities and differences of these aspects in regards to application and game based computational systems.

- It has opened the door for further research into exploration in web environments and the use of task analysis and modelling in the user exploration context.
IS Practice Community:

- It has provided a powerful tool for user interface and web designers, with the development of a task model formalism that incorporates aspects of navigational exploration in the web context. Moreover, the added phase process has given designers the potential to understand why deviations are occurring from common tasks within the site, which may cause user frustration, abandonment of the site, as the result of page aesthetics, structure or layout issues. It may be used to provide more effective and efficient navigational structures that cater for exploration.

8.4 Conclusion

This research has provided some interesting results in regards to the application of exploratory behaviour, and the use of navigating methods in both the structured and unstructured environments in the web context. These results provided the development of the exploratory criteria, and its use in the development of DIANE\textsuperscript{nx} task model. A two-phase modelling process was introduced, providing user interface and web designers the ability to model individual exploration from several users, and then using the phase two to consolidate deviations from pages of the intended task path indicated by the designer. Furthermore, limitations and future research were discussed. In conclusion, the research has contribute a significant amount of knowledge to the IS practice and research community.
References


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Dillion A, McKnight C and Richardson J, (1993), ‘Space – the Final Chapter or Why Physical Representations are not semantic intentions’, in C McKnight, A Dillion, J Richardson (eds), *Hypertext: a psychological perspective*, Ellis Horwood Ltd.


Appendix

Appendix A: Task Descriptions and Websites Observed
### APPENDIX A-1: TASK DESCRIPTIONS

<table>
<thead>
<tr>
<th><a href="http://www.bt.com">www.bt.com</a></th>
<th>British Telecom</th>
<th>Structured Environment</th>
</tr>
</thead>
</table>
| **Task 1**  | You live in Britain, and your telecommunication provider is British Telecom. You are currently receiving anonymous calls on your home phone. On these occasions you answer the phone and hear silence from the caller. After repeat ably prompting a conversation, you still receive no response and proceed to hang up. You are unable to retrieve the caller’s number since your caller display is showing ‘private number’.

You would like to know if there is a call feature that BT provides to customers that automatically rejects anonymous calls. |

<table>
<thead>
<tr>
<th>Intended page path.</th>
<th>Homepage &gt; At Home &gt; Product &amp; Services &gt; Call Feature &gt; Advanced Features &gt; Anonymous Calls</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 2</strong></td>
<td>You would like to find the solution, ‘Self Service Voice’ for corporate customers.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><a href="http://www.projectmiso.net">www.projectmiso.net</a></th>
<th>ProjectMiso</th>
<th>Unstructured Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 1</strong></td>
<td>You would like to send an email to projectmiso.net asking for quote details on various projects. Please list all the components of the email form provided on projectmiso.net site.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Intended page path.</th>
<th>Email &gt; (Select Components) [Company, Phone, Name, Email, Subject, Message]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task 2</strong></td>
<td>You would like to know what the main services Projectmiso.net provide?</td>
</tr>
</tbody>
</table>

| Intended page path. | Info > Services > [Data Modeling, Imaging and Multimedia, Web development, Internet Marketing, Project Management] |
APPENDIX A-2: STRUCTURED AND UNSTRUCTURED SITE SCREENSHOTS
British Telecom (BT.com) Screenshots

Home Page

At home
for residential users to view a list, select new services or buy a product online.

Small and medium business
with 1 to 500 employees. Products and services to suit the nature and size of your business.

Corporate
with 500+ employees. BT's experience and global capability can deliver solutions for your business.

Public sector
for public sector businesses. BT can provide more solutions that you can rely on.

Directory Enquiries - 118 500
Find the phone numbers for people and businesses in the UK.

For more features and a better experience, log in.
Log in Name
Password
Register Now
Forgotten login details?

‘At Home’ Page

At home
Nothing brings your interests to life like Broadband.

Products & call options
BT Together calling options
Buy shares & save online
Get another BT line
Reconnect to BT
BT Calling features

Account management
BT Online - call setup
View my bill
Pay my bill
Friends & Family
Moving home

Innovations from BT
118 500 Directory Enquiries
BT Mobile Home fibre
Home Computing
Home Networking
Home Monitoring

Privacy policy
Appendix B: Sample Experiment Result Spreadsheet
2. Exploration Navigation

<table>
<thead>
<tr>
<th>No.</th>
<th>Hyperlink Name</th>
<th>Navigation Section (N#-#)</th>
<th>Feedback</th>
<th>Comment/Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>At Home</td>
<td>PH</td>
<td>&quot;...I use the internet mainly at home - personal base decision&quot;</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Broadband</td>
<td>N2-1</td>
<td>&quot;Got cable internet at home - some connection&quot;</td>
<td>Instantly focused on left navigation bar. Assumed heading was hyperlink - not more info at first.</td>
</tr>
<tr>
<td>3</td>
<td>BT Broadband for home</td>
<td>PH</td>
<td>&quot;Looks interesting&quot;</td>
<td>Scanned contents on page. View demo stood out. Looked at the graphics first.</td>
</tr>
<tr>
<td>4</td>
<td>Broadband Demo</td>
<td>PH</td>
<td>&quot;Had enough of looking at it&quot;</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>How fast [pop-up]</td>
<td>PH</td>
<td>&quot;Interested to know why&quot;</td>
<td>Interest.</td>
</tr>
<tr>
<td>6</td>
<td>[Closed window]</td>
<td>PH</td>
<td>&quot;Randomly looking - not interested anymore&quot;</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Why choose BT [pop-up]</td>
<td>PH</td>
<td>&quot;Wanna go back to the page I started at&quot;</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Email</td>
<td>PH</td>
<td>&quot;Don't know where to look&quot;</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>[Back button]</td>
<td>N2-9</td>
<td>&quot;Into mobile phones&quot;</td>
<td>Scanned over sections in content.</td>
</tr>
<tr>
<td>10</td>
<td>Free Nokia [Ad]</td>
<td>PH</td>
<td>&quot;Looking at the different boxes&quot;</td>
<td>Observed ad on right hand side. The word FREE attracted her.</td>
</tr>
<tr>
<td>11</td>
<td>Nokia 6610 [Ad]</td>
<td>PH</td>
<td>&quot;Wanna go back to the page I started at&quot;</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Mobile</td>
<td>N2-0</td>
<td>&quot;Let's look at something else&quot;</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>In Business</td>
<td>N1-2</td>
<td>&quot;[Clicked it] ...cause mouse over it&quot;</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Corporate</td>
<td>PH</td>
<td>&quot;Don't know where to look&quot;</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Product &amp; Services</td>
<td>PH</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. General Comments

<table>
<thead>
<tr>
<th>No.</th>
<th>Question</th>
<th>Answer</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td></td>
<td>&quot;It would be different if there was clear task formation. No direction.&quot;</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C: Data Coding Spreadsheet Example
### Theme development for Structured Environment

#### Exploration

<table>
<thead>
<tr>
<th>Themes</th>
<th>Possible related themes</th>
<th>Observed</th>
<th>Appears in</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content scanning</td>
<td>Heading before text</td>
<td>1</td>
<td>2-1</td>
<td>&quot;I scan the headings&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>2-7</td>
<td>&quot;Basically when I go into a site I will look at the headings and translate myself&quot;</td>
</tr>
<tr>
<td>Content before navigation</td>
<td>Heading before navigation</td>
<td>2</td>
<td>2-3</td>
<td>&quot;Start reading the headings then scan&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>2-10</td>
<td>&quot;Don't look at navigation unless I need too&quot;</td>
</tr>
<tr>
<td>Unfamiliarity</td>
<td></td>
<td>2</td>
<td>3-0</td>
<td>&quot;In unfamiliar web sites I usually use content hyperlinks not the main&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td>2-4</td>
<td>&quot;Headings and sub-section stand out.&quot;</td>
</tr>
<tr>
<td>Text</td>
<td>Read if heading had revelance</td>
<td>2</td>
<td>3-2</td>
<td>&quot;Only look at text if it had anything relevant...&quot;</td>
</tr>
<tr>
<td></td>
<td>Only read if disperate or close</td>
<td>3</td>
<td>3-4</td>
<td>&quot;Only read the text if I am getting disperate or really really close&quot;</td>
</tr>
<tr>
<td>Confusion</td>
<td></td>
<td>9</td>
<td>2-3</td>
<td>&quot;This is quite confusing, word everywhere and jumbled&quot;</td>
</tr>
<tr>
<td>Colours</td>
<td>No revelance</td>
<td>2</td>
<td>3-4</td>
<td>&quot;Colours did nothing special&quot;</td>
</tr>
</tbody>
</table>

#### Abstract Goal/Task formation

<table>
<thead>
<tr>
<th>Themes</th>
<th>Possible related themes</th>
<th>Observed</th>
<th>Appears in</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spend a while on one page</td>
<td></td>
<td>1</td>
<td>2-4</td>
<td>&quot;Choose him cause he was the first one, don't really have a goal! &quot;</td>
</tr>
<tr>
<td>No clear answer on choices made</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>Visit sites of interest.</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Search</td>
<td>Used to help form task</td>
<td>3</td>
<td>2-3</td>
<td>&quot;I don't know where to go 'cause nothing appeals to me&quot;</td>
</tr>
</tbody>
</table>

#### Changes in Task Formation

<table>
<thead>
<tr>
<th>Themes</th>
<th>Possible related themes</th>
<th>Observed</th>
<th>Appears in</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using interest to form tasks.</td>
<td></td>
<td>1.2-4, 2-7, 6</td>
<td>2-5</td>
<td>&quot;Looks interesting&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td>2-1</td>
<td>&quot;Broadband, would like to get it at home&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>2-2</td>
<td>&quot;I'm clicking on anything&quot;</td>
</tr>
<tr>
<td>Short term goal</td>
<td></td>
<td>9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Task exploration ended

<table>
<thead>
<tr>
<th>Themes</th>
<th>Possible related themes</th>
<th>Observed</th>
<th>Appears in</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>No task formed</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Go back to home page</td>
<td></td>
<td>6</td>
<td>2-19</td>
<td>&quot;Don't know where to look&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3-0</td>
<td>&quot;It would be different if there was something that I was interested in&quot;</td>
</tr>
<tr>
<td>Can't find task goal</td>
<td></td>
<td>7</td>
<td>2-10</td>
<td>&quot;Can't find what I was looking for&quot;</td>
</tr>
</tbody>
</table>

#### Content blockout

<table>
<thead>
<tr>
<th>Themes</th>
<th>Possible related themes</th>
<th>Observed</th>
<th>Appears in</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advertising</td>
<td></td>
<td>1</td>
<td>2-8</td>
<td>&quot;Advertising I block out&quot;</td>
</tr>
<tr>
<td>Category</td>
<td>Action</td>
<td>Page(s)</td>
<td>Notes</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Discovery</strong></td>
<td>Trying hyperlinks or menu items</td>
<td>1</td>
<td>2-9 “The reason why I clicked on (Career Zone), didn't understand the sub menus.”</td>
<td></td>
</tr>
<tr>
<td><strong>Landmark - Pages that revealance</strong></td>
<td>Used to go back to relevant page</td>
<td>1, 2, 3</td>
<td>3.2-5 “Press back because I know I will get back to the page I was previously on”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used right mouse button</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Do not remember page. Watch out for far</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Constant back button use, no navigation use</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used to go back home in indepth navigation</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Back button mistake</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Forward button</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>New window</strong></td>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Navigation used</strong></td>
<td></td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Map</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Site Map</strong></td>
<td>Back and forth motion</td>
<td>1</td>
<td>2-10 “Try to form a picture in my head of the structure of the site”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>First page of exploration</td>
<td>3</td>
<td>2-1 “Look at site map - so I know what is in the site”</td>
<td></td>
</tr>
<tr>
<td><strong>Route</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Remembering number of back buttons</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Site Usability problems.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Search</strong></td>
<td>Pointed out.</td>
<td>2</td>
<td>2-9 “Should had map of areas available instead of postcode”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Inconsistent search facility</td>
<td>3</td>
<td>3-3 “Search facility was not consistent”</td>
<td></td>
</tr>
<tr>
<td><strong>Bookmark</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pages within loaded pages</strong></td>
<td>Confusion on &quot;next&quot; hyperlink, believe it</td>
<td>8</td>
<td>2-9 “Only press back button if there are not pages inbetween”</td>
<td></td>
</tr>
</tbody>
</table>
Appendix D: DIANE+ Formalism
APPENDIX D-1: OPERATIONS NOT CONSIDERED IN DIANE\textsuperscript{NX}

Manual Operation

\textit{DIANE\textsuperscript{+} Definition:}
An operation that is performed by the user. There is no interaction with the system.

\textit{Relation to modelling exploration:}
The manual notation will not be required in modelling exploration. The exploratory model enables designers to capture the user’s exploration. The manual operation has no purpose in task exploration.

Mandatory Operations

\textit{DIANE\textsuperscript{+} definition:}
An operation that must be processed.

\textit{Relation to modelling exploration:}
The model represents the user’s interaction with the system; therefore a mandatory operation is not required given this.

Optional Operation

\textit{DIANE\textsuperscript{+} definition:}
An operation that is optional.

\textit{Relation to modelling exploration:}
The option of clicking on a particular navigational aid, or the loading of a page is not present in modelling task exploration.

Sequence Precondition

\textit{DIANE\textsuperscript{+} definition:}
Condition under which the link is to be followed.

\textit{Relation to modelling exploration:}
The sequence precondition is not required for modelling task exploration. However, this method may be used for representing navigation aid selection, although this defeats the purpose of sequential enhancement to the model and the use of the interaction operation.

Parallelism

\textit{DIANE\textsuperscript{+} definition:}
DIANE\textsuperscript{+} provides the ability of capturing operations in parallel.

\textit{Relation to modelling exploration:}
The process of engaging in multiple tasks at the same time is not applicable for task exploration. The modelling of user exploration is a sequential process.

Feedback
**DIANE+ definition:**
The feedback provided to the user from the system.

**Relation to modelling exploration:**
There is no need for feedback in modelling exploration. The model is capturing user actions not system responses.
The exploration modelling descriptions and usage reference appropriate sections accordingly in the thesis.

**Automatic Operation**

*DIANE+ Definition:*  
An operation performed by the system only.

*Relation to modelling exploration:*  
The loading of a site page is a major component of exploration and is the only system oriented operation.

*Exploration modelling description:*  
Represents the name of the page loaded after the selection of a navigation aid.

*Usage Rules:*  
1. Applied before a page interaction or page jump operation (5.4.1.2).

**Terminal Node Operation**

*DIANE+ Definition:*  
Indicates the termination of a task.

*Relation to modelling exploration:*  
Necessary in representing the end of the users exploration.

*Exploration modelling description:*  
Represents the termination (or end) of the users exploration. The task is not required to be complete.

*Usage Rules:*  
1. Applied after a automatic operation, page jump, backward, or forward operation (5.4.1.2).
**DIANE+ definition:**
Condition that must be true for the operation to be applicable.

**Relation to modelling exploration:**
The precondition operation can be used in representing the keywords entered into the search facility (criteria element, section 5.1.5). The precondition operation along with the interaction operation will represent the search; this represents the navigation aid that is to be selected once the keywords are entered.

**Exploration modelling description:**
Used in defining a search facilities keywords entered by the user.

**Usage Rules:**
1. Applied above a page interaction operation. The page interaction operation represents the navigation aid, which is selected after the search keywords are entered.
2. If the search page is sequentially accessed multiple times, a number is placed before each keyword entry, associated to the iteration of the automatic operation (search page). (see iteration constraints)

**Boolean Operators**

**DIANE+ definition:**
An operation is synchronised with another (AND), or when there exists a choice between operations (OR, XOR).

**Relation to modelling exploration:**
Not applicable in the exploratory model, though the use of an OR connection enables the designer to represent the multiple deviations in a deviation sub-task of phase two (discussed further in chapter 6 – phase two).

**Exploration modelling description:**
OR operator used in Phase 2, indicating multiple deviations from a page.

**Usage Rules:**
1. Applied within a deviation sub-task operation (see composite operation).

**Task Sequence**

**DIANE+ definition:**
Indicates the order of the operation to be performed.

**Relation to modelling exploration:**
It represents a connection between operations, and therefore a vital notation of the exploratory model.

**Exploration modelling description:**
Connection link between operations.

**Usage Rules:**
1. Applied between operations performed using the same navigational aid section (discussed further in section link, 5.4.1.2).

**Iteration constraints**
**DIANE+ definition:**
An operation that has a number of iterations.

**Relation to modelling exploration:**
Iteration constraints can be applied to the back tracking and forward tracking criteria processes (element criteria, section 5.1.1). It was observed that in some cases when participants applied the backward tracking process, they moved forward again to pages previously visited (identifying a page landmark) – iteration between pages. Furthermore, this operation provides usage for distinguishing routes along paths.

**Exploration modelling description:**
Indicates repetition of a back or forward, automatic and page interaction operations.

**Usage Rules:**
1. Placed within the bottom right hand corner of the operation.

---

**Composite Operations**

**DIANE+ definition:**
An operation that has sub-tasks.

**Relation to modelling exploration:**
DIANE+ allows the ability of representing sub-tasks in a task (excluding Manual operation). The exploratory model does not require sub-tasks. The process of exploration is sequential, and models the interaction of navigational aids. However, the composite operation is required for representing phase two’s deviation consolidations, sub-tasks will indicate the multiple deviations from associated page (discussed in chapter 6 – phase two).

**Exploration modelling description:**
Used in phase 2, identifies deviation sub-tasks for the composite automatic interaction.

**Usage Rules:**
1. Each page in the designers intended page path is a composite automatic operation. The deviations from these pages are considered sub-tasks.

---

**Elementary Operations**

**DIANE+ definition:**
An operation that require no sub-tasks.

**Relation to modelling exploration:**
All operations within the exploratory model are represented as elementary..

**Exploration modelling description:**
All notations are elementary in the model they are performed by the user.

**Usage Rules:**
1. Normal outlined operations.
Appendix E: DIANE$^n_x$ Task Scenario Walkthroughs
APPENDIX E-1: Multiple Opening of New Windows Walkthrough

DIANE+ Representation

DIANE* Representation

= Indicates the repetition of pages.
= Indicates a page which belongs in the intended navigational path.
Section 1: Inner window opening within secondary window

- Backward operation with a new window notation captures the following:

The operation displays that the opening of a window within a secondary window (multiple windows). As stated in the backward operation usage rules, a backward operation within another is performed as it is represented, if there is a direct sequence connection to that operation. In this case, the user opened a new window from the ‘products & service’ page, loading the ‘useful information’ page. They then closed the window and returned to the secondary window state. From there they proceeded on, indicating ‘products & services’ as a landmark operation, since the user navigated forward from a backward operation.

Section 2: Outer secondary window opening

- Backward operation with a new window notation captures the following:

As discussed in Scenario 1, this operation represents the opening of a new window (indicated by the new window notation). The user, from the ‘customer service’ page, opened a window containing the ‘BT Together Calling Options’ page, continued onto the ‘Products & Services’ page within the same window, and from there opened a third window (Scenario 1), while both the original and secondary windows were still opened. They then proceeded on, after the closure of the third window, from where they last left off in the secondary window ending at the ‘Search/Site Map’ page.

To represent the opening and minimisation of windows, the same backward operation usage rules apply as for the closure of windows. Once the user maximises the window to the original state the navigational page jump is applied representing the last page loaded before minimising within a new backward operation and new window notation.

If the user does not close or minimise the window whilst exploring, then the application of this operation is not required, since there is no clear identification of a landmark.
APPENDIX E-2: Search Walkthrough

DIANE+ Representation

DIANE^nx Representation
Section 1: Using a search page

- Pre-condition attached to an interaction operation captures the following.
  Search/Site Map Page [Search Keywords before GO Hyperlink is clicked on].

  After navigating to the ‘Search/Site Map’ page, the user enters search keywords within the search text box before proceeding to click on the GO hyperlink. The pre-condition details the information entered before hitting the navigational aid (GO in this scenario), which then loads the search result page.

Section 2: Using a search multiple times

- Pre-condition attached to an interaction operation, and an iteration within a navigational aid jump captures the following:
  Search Results Page > Search Results Page
APPENDIX E-3: Identifying Routes Walkthrough

DIANE+ Representation

DIANE^nx Representation
Section 1: Identifying a route

The route operation captures the following:
Calling Features > Call Sign > 24/7 > Calling Features > Call Sign > 24/7

The pages listed above are visited twice, in the same sequential path. To reduce the
representation of these pages and their navigation aids, the route operation is applied
around them. The iteration, number two, represents the number of times the route was
taken sequentially. The first and last pages, ‘Calling Features’ and ‘24/7’ respectively,
are modelled as landmark pages. After the last page in the 2nd iteration was complete,
the user proceeded to the ‘Advanced Features’ page.

The route operation does not model pages visited sequentially by the use of different
navigational aids, this is represented using the navigational aid jump operations. A route
is not clearly defined with this use.