Representation and Reorganization of Web Accessibility Guidelines Using Goal Graphs and Design Patterns

by

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To my wife, Talat, and my mom and dad

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Abstract

Web accessibility guidelines have textual representation and provide little support in systematic analysis and usage. The study hypothesizes that the guidelines can be reorganized and represented using the goal oriented technique and design patterns which will allow their usage in a more systematic manner and accommodate detailed analysis of the guidelines with other competing goals. For this study, knowledge from web designers' experiences in using the guidelines, researchers' findings, and the actual guidelines have been amalgamated. Six web designers have been consulted on a one-on-one basis and difficulties in using the guidelines for (1) specific scenarios, (2) systematic application, and (3) detailed systems analysis have been reported. Goal oriented modeling and design patterns have been introduced for (1) graphical representation of the guidelines using goal graphs, and (2) keeping the technical details separate from the goal graphs. The proposed representation allows for the accessibility guidelines to be systematically applied into interface design, and systems design using the goal oriented modeling technique.

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Chapter I: Introduction

I.1 Statement of the problem

The study analyzes the representation of the current web accessibility guidelines used by the web designers to analyze the effort that the designers are required to put in understanding the guidelines, and the difficulties in achieving compliance to the guidelines. Through this greater understanding, alternate and supplementary representations of the accessibility guidelines are analyzed and developed. Specifically, the study considers the use of goal graphs and design patterns as possible means for representing the guidelines in a reorganized manner.

I.2 Statement of the purpose

The purpose of this study is to perform an analysis of the way that goal graphs can be used in conjunction with design patterns to reorganize the web accessibility guidelines. As a result of this reorganization, the other purposes of the study are to:

- explore the possible applications of the reorganized guidelines using goal graphs in designing accessible web contents
- analyze the abilities of the reorganized guidelines to be included in the design phase of system design process
- assess the ability of the reorganized guidelines to be applied for accessibility evaluations
- analyze the ability of the reorganized guidelines to promote a holistic approach in performing accessibility designs
- analyze the applicability of goal oriented modeling in accessibility research

- explore the possible extensions to the conventional goal oriented modeling for making it applicable to the user interface design process

I.3 Research questions

The study explores the different possibilities and tries to meet its purpose by asking the following research questions at different stages of the research:

- What is the current form of representation of web accessibility guidelines, and what are the possible difficulties that web designers may face in using such guidelines?
- Is goal oriented modeling technique applicable in conveying the web accessibility principles as goals, so that they can be analyzed, prioritized, and achieved by the means of goal operationalization? And if so, can design patterns be used to help this reorganization of accessibility guidelines and make their application easier for the web designers?
- What are the possible techniques that one can use the reorganized guidelines in using the goal graphs and design patterns? And what are the extensions to conventional accessibility research that is required for one to do so?
- What are the possible areas (such as performing goal analysis, designing information systems, and applying in a holistic approach) where the existing accessibility guidelines cannot be used in a systematic manner? Can the newly reorganized guidelines take advantage of their representations and be used in such areas?

I.4 Significance of the study

The Web Accessibility Initiative (WAI) by the World Wide Web Consortium (W3C) in 1997 has successfully raised awareness in the web design community about issues related to access to information on the web by disabled users. It raises awareness about certain types of barriers to receive information over the web and aims at proposing solutions that will reduce the barriers significantly.

Barriers to receiving free information may fall under government discrimination acts in many countries. For example, the Disability Discrimination Act (DDA) in the UK (Hackett, Parmanto, & Zeng, 2005), Americans with Disabilities Act (Johnson & Ruppert, 2002) in the US, and the Australian Disability Discrimination Legislation (Wallis, 2005) in Australia consider that web contents be equally accessible to all citizens of their nation. In Canada, the government has taken a step forward in creating any of its governmental sites with accessibility features since 1995 (Slatin & Rush, 2003), thus making compliance to accessibility guidelines a requirement at the government level.

Web content accessibility guidelines have been in use for several years in many governmental and non-governmental organizational web sites, and have successfully raised awareness about accessibility of web site contents in the research community. Even though it has been in use for several years, it has not been successfully adopted by the web design community. Many studies have been done in attempts to find the reason for the failure of these guidelines to be successful in the design community. However, there has not been any definitive answer to the problem.

By building on observations by researchers that the guidelines are often too bulky (Thatcher, 2002; Lazar et. al., 2004), that accessibility may be considered as a quality requirement (Schimiguel, Melo, Baranauskas & Medeiros, 2005), and that goal oriented modeling technique can provide an excellent mechanism for representing the quality

requirements (Chung, Nixon, Yu & Mylopoulos, 2000), this study considers the fact that the representation of web content accessibility guidelines using goal graphs and design patterns may provide significant help in using the accessibility guidelines in web design. This study aims at filling an apparent gap in research on how the accessibility guidelines can be graphically represented using certain modeling techniques. Furthermore, it aims at filling the gap in research by providing a systematic approach using which accessibility guidelines can not only be applied in web designs, but can also be used for system designs, and for performing accessibility evaluations in a detailed manner.

I.5 Limitations of the study

There are two limitations of the study. First, the participants of the research do not represent the entire web designers' population as it only involves the participation of six web designers. However, the consultations with the web designers have not been used empirically in the research. They have rather been used in guiding the reorganization of the accessibility guidelines.

Second, the study only considers the Web Content Accessibility Guidelines (WCAG) and their representation. Although it briefly looks at other types of accessibility guidelines, such as the User Agent Accessibility Guidelines (UAAG), and Adaptive Technology Accessibility Guidelines (ATAG) (discussed in the literature review), the study does not consider these accessibility guidelines at a deeper level for increased understanding. However, the reorganization of the accessibility guidelines proposed in this research can potentially be applied for representing all types of accessibility guidelines. Furthermore, the study does not aim at performing a research on accessibility, as its aim is only to perform a research on how their representations are made and how they are being used.

Chapter II: Literature review

II.1 Web accessibility and guidelines

In this part, I shall start by providing a detailed understanding on the background of web accessibility. I shall then discuss about the accessibility guidelines that have been proposed by research groups. Since this research is concerned with the ability of the guidelines to provide sufficient guidance to web designers in designing accessible web sites, I shall begin by critiquing these guidelines based on relevant research findings. The critique of these guidelines will help in guiding the discussion towards the two techniques that can help mitigate some of the problems around the usage of the guidelines by the web designers.

II.1.1 Web accessibility

Accessibility, as it refers to the usage in the web environment, has been defined by different researchers in quite different ways. Milne (2005) describes web accessibility as the ability of a diverse range of users to be able to use web contents. Hackett, Parmanto, and Zeng (2005) define web accessibility in similar terms, except that they explicitly include persons with disabilities into the diverse user groups. Brajnik (2004) takes the concept a step further by specifying the requirement of the user to be able to perceive, operate, and understand its contents, regardless of their disability. Considering the three definitions of accessibility, it can be said that accessibility is the ability of a diverse set of users, including users with or without induced disabilities, to be able to perceive, operate, and understand the contents of a web site.

The term disability is often misleading in the case of accessibility research. Disability can be considered to be based on visual, physical, or mental capabilities of a subject. While Hackett, Parmanto, and Zeng (2005) consider only visual and physical impairments as disabilities, Hanson et. al. (2005) assume that age-based impairments should also be considered as disabilities. This is because, with age, users may become physically less capable. Hansen et al. (2005) argue that people have different combinations of problems that may term them as disabled, but they nevertheless are not commonly called disabled. Thus, for the purpose of this research, disability is going to be considered as an induced problem, or a set of induced problems, that may limit a user from accessing web contents in an effective manner.

Since different types of disabilities limit certain aspects of the usage of a web site, they require different mechanisms for accessing a web site. While visually disabled users use technologies such as screen readers (Slatin & Rush, 2003) to access web contents, physically disabled users may use technologies such as alternative pointing devices for navigating web contents (Lazar, Dudley-Sponaugle, & Greenidge, 2004). Sometimes, a set of different types of disabilities, such as blindness along with motor disability, may create unique situations where these accessibility technologies may simply fail (Hanson et. al., 2005). From this perspective, it becomes evident that it is difficult to respond to such a diverse set of user requirements based on their capabilities to use web sites. This is because, while blindness may require some aspects of web contents to be interpretable in one way, motor disability may require the web contents to be interpreted in a different way.

It may be already evident that web accessibility research revolves around making web contents available to all users irrespective of their difficulties in perceiving the contents of the web. If it is looked at from a different perspective, it becomes evident that the issue revolves around different presentation techniques of the same web content, where the different presentation techniques will help present the contents to users with different disabilities in rendering the web contents. Noting this, Hull (2004) proposes a radical idea which considers making web contents accessible to technologies first, and then to the

users that use it. The underlying idea is that web contents be separated from its presentation, such that the contents can be used via a technology of the user's choice.

The view of web contents as separate from its presentation brings into light the different components that are necessary to coordinate well in order for web contents to be accessible. The Web Accessibility Initiative (WAI) (W3C, 2006a) is an initiative that has been taken to coordinate the strategies, guidelines, and resources to help make accessible web contents. This is an initiative taken by the World Wide Web Consortium (W3C), and considers approaching web accessibility from three interdependent perspectives (Chisholm & Henry, 2005).

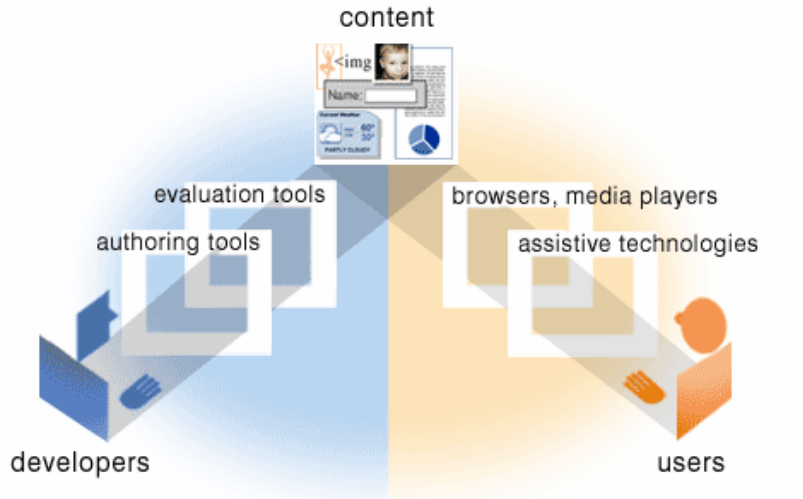

Figure II.1: The interdependent components of web accessibility (W3C, 2006d)

The interdependencies between the components shown in the figure II.1 are based on not only the users' usage of web contents, but also the developers' ability to produce such contents. The dependency can be seen by taking the example of an alternative text (known as alt text in HTML) that is shown in figure II.2.

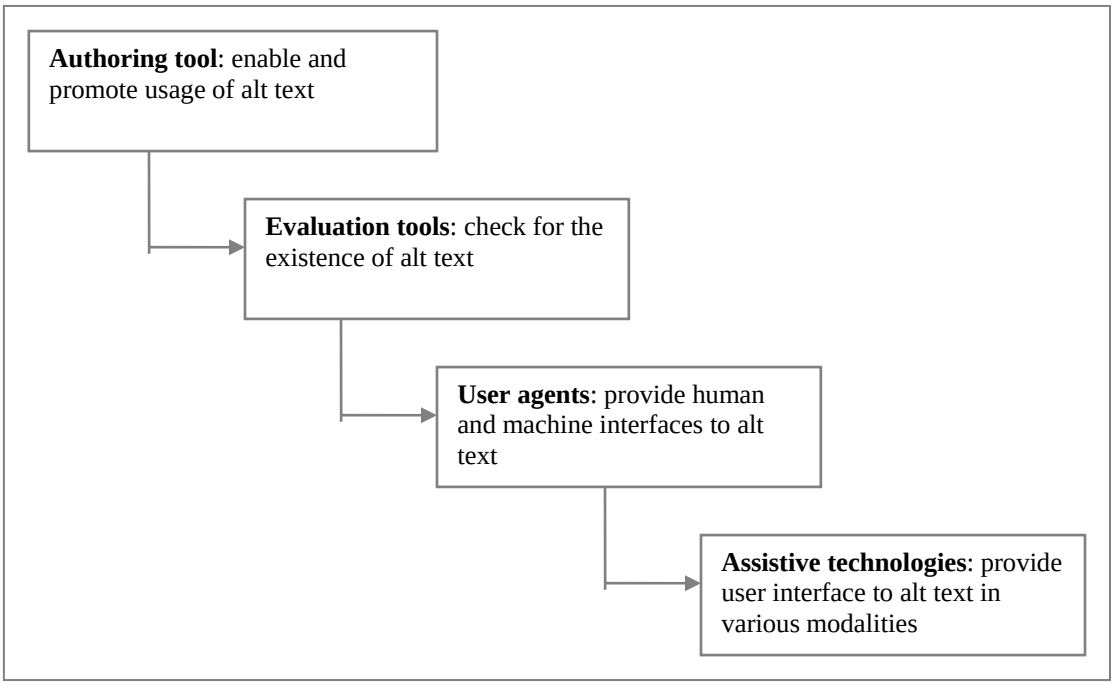

Figure II.2: The interdependent components that work to achieve web accessibility using alternative texts

Alternative texts are textual components that can act as representations for non-textual components of a web page. Since web sites can contain multimedia components, such as images and videos, textual components are necessary for different types of users. For example, for a blind user, the alternative text of an image will be able to tell the user what the image is about. However, the user is dependent on not only the ability of the assistive technologies (in the case of a blind user, it may be a screen reader) to be able to interpret the alternative texts into a format the user can understand. Since authoring tools are the ones that are used to produce web page contents, the user is dependent on its ability to accept alternative texts for non-textual components of the web page from its designers. The user is also dependent on the ability of evaluation tools to check the availability of alternative texts for all non-textual components of a web page, and the user agents to be able to provide an interface between the user and the machine for the alternative text.

II.1.2 Web accessibility guidelines

Based on the interdependent components required to achieve web accessibility, we can perceive it in similar terms to that of WAI. That is, we can consider accessibility to be based on the web contents by themselves, the authoring tools that have been used for making such accessible web contents, and the user agents that are used to access the web contents.

II.1.2.1 Guidelines for accessible web contents

The most commonly used guideline for accessible web contents is the Web Content Accessibility Guidelines (WCAG) 1.0. It has become available in 1999 (Chisholm, Vanderheiden, & Jacobs, 1999), which consisted of 14 guidelines (Hackett, Parmanto, & Zeng, 2005) in three levels of checkpoints on creating accessible web sites.

WCAG 1.0 has three levels of checkpoints, Level A, AA, and AAA (Clark, 2003). Level A provides some general guidelines that may be able to make a web site accessible to the minimum. Some of the issues that Level A covers are alt texts for images, text color being irrelevant in providing meaning for the text, issues with identification of the rows and column headers of tables, equivalent description of multimedia contents in text, audio, and any usable formats, and the suggestion to create an alternative page for accessibility if the regular page design cannot be compromised (Clark, 2003). Level AA of the specification includes requirements for color contrast between back and foregrounds, use of markup rather than images for conveying information, not to use tables for page layout unless the linearized form of the table would not flow in the day that the designer has envisioned, and having scripts and applets accessible to assistive technologies (Clark, 2003). Level AAA of the specification is firm several specific issues, such as the use of abbreviation of terms in documents that it first occurs in, logical tab order set up for forms and other fields in the page, and allowing users to search at different levels of complexities according to different user needs (Clark, 2003).

To meet level A conformance, the design has to meet all the requirements imposed in that level. Level AA conformance, however, requires that the design meets all the requirements of level A and all the requirements of level AA. Finally, level AAA requires that the design meets level A and AA requirements (Clark, 2003; Hackett et. al., 2005).

Version 2.0 of WCAG (Vanderheiden & Chisholm, 2002) is a working draft and addresses accessibility issues in more depth. It has made a few significant changes in its approach from that of version 1.0. The working draft of WCAG 2.0 published on December 11, 2007 suggests that it builds on its preceding version by making the guideline more broadly applicable to different web technologies (Caldwell et al., 2007a). The guideline takes a rather principle-centered approach rather than the technique-centered approach taken by its predecessor (WebAim, n.d.). By principle-centered approach, it means that the guidelines start by looking at a principle and its breakdowns, and then provides an approach as a solution for that principle. There are clearly a few major additions to the guideline that are worth noting. Since the approach is now principle-centered, the guideline has now been made more technology independent. Thus, the solutions are more related to a recommendation of how things should be, rather than how it is done in a specific technology (such as HTML).

For a better understanding of the differences between WCAG 1.0 and WCAG 2.0, following are two guidelines from the two versions. The first one is guideline 4 from WCAG 1.0 which aims at making it easier for users to identify the natural language used in the web contents. The second one is a portion of principle 3 which aims at solving similar issues as the first one. Both guidelines are represented textually[1], and require the user of the guidelines to read and comprehend the message that these guidelines are trying to convey. They both make good use of hyperlinks (shown using the underlined

[1] One reason for the textual format of an accessibility guideline is presumably for the need of the guideline to be accessible itself. See the study by Colwell and Petrie (2001), which assesses accessibility of WCAG.

texts in figures II.3 and II.4) for relating to another guideline or to guide the user to a better understanding on the meaning of a term, phrase, or the guideline itself.

Guideline 4. Clarify natural language usage

Use markup that facilitates pronunciation or interpretation of abbreviated or foreign text.

When content developers mark up natural language changes in a document, speech synthesizers and braille devices can automatically switch to the new language, making the document more accessible to multilingual users. Content developers should identify the predominant natural language of a document's content (through markup or HTTP headers). Content developers should also provide expansions of abbreviations and acronyms.

In addition to helping assistive technologies, natural language markup allows search engines to find key words and identify documents in a desired language. Natural language markup also improves readability of the Web for all people, including those with learning disabilities, cognitive disabilities, or people who are deaf.

When abbreviations and natural language changes are not identified, they may be indecipherable when machine-spoken or brailled.

Checkpoints:

4.1 Clearly identify changes in the natural language of a document's text and any text equivalents (e.g., captions). [Priority 1]

For example, in HTML use the "lang" attribute. In XML, use "xml:lang".
Techniques for checkpoint 4.1

4.2 Specify the expansion of each abbreviation or acronym in a document where it first occurs. [Priority 3]

For example, in HTML, use the "title" attribute of the ABBR and ACRONYM elements. Providing the expansion in the main body of the document also helps document usability.
Techniques for checkpoint 4.2

4.3 Identify the primary natural language of a document. [Priority 3]
For example, in HTML set the "lang" attribute on the HTML element. In XML, use "xml:lang". Server operators should configure servers to take advantage of HTTP content negotiation mechanisms ([RFC2068], section 14.13) so that clients can automatically retrieve documents of the preferred language.
Techniques for checkpoint 4.3

Figure II.3: Guideline 4 of WCAG 1.0 (Chisholm, Vanderheiden, & Jacobs, 1999)

Principle 3: Understandable - Information and the operation of user interface must be understandable

Guideline 3.1 Readable: Make text content readable and understandable Understanding Guideline 3.1

3.1.1 Language of Page: The default human language of each Web page can be programmatically determined. (Level A) How to Meet 3.1.1 Understanding 3.1.1

3.1.2 Language of Parts: The human language of each passage or phrase in the content can be programmatically determined except for proper names, technical terms, words of indeterminate language, and words or phrases that have become part of the vernacular of the immediately surrounding text. (Level AA) How to Meet 3.1.2 Understanding 3.1.2

3.1.3 Unusual Words: A mechanism is available for identifying specific definitions of words or phrases used in an unusual or restricted way, including idioms and jargon. (Level AAA) How to Meet 3.1.3 Understanding 3.1.3

3.1.4 Abbreviations: A mechanism for identifying the expanded form or meaning of abbreviations is available. (Level AAA) How to Meet 3.1.4 Understanding 3.1.4

3.1.5 Reading Level: When text requires reading ability more advanced than the lower secondary education level, supplemental content, or a version that does not require reading ability more advanced than the lower secondary education level, is available. (Level AAA) How to Meet 3.1.5 Understanding 3.1.5

3.1.6 Pronunciation: A mechanism is available for identifying specific pronunciation of words where meaning is ambiguous without knowing the pronunciation. (Level AAA) How to Meet 3.1.6 Understanding 3.1.6

Figure II.4: Principle 3 of WCAG 2.0 (Caldwell et al., 2007a)

The differences between the two guidelines based on an analysis of their approach in providing the information to the user of the guidelines are provided in table II.1. Essentially, the two guidelines take two very different approaches at conveying the message to the audience. The guideline in figure II.3 starts with a quite elaborative analysis of the requirement of the guideline. This may provide the reader with an understanding of the overall situation on why this guideline may be used. In contrary, the guideline in figure II.4 seems to get the reader involved into acting based on principles. In contrary to the checkpoints used in the guideline in the first guideline, this guideline provides the user with the ability to achieve a goal that is represented using a principle.

WCAG 1.0	WCAG 2.0
The guideline starts with a detailed understanding of the reason why the certain accessibility feature is necessary.	The guideline lists the principles that it aims at approaching, but provides a hyperlink to a page with information on the need of having the guideline
The guideline is comprised of checkpoints	The guideline is comprised of principles
Each guideline is provided with its own priority level; priority levels determine the impact of a guideline on accessibility;	Each guideline belongs to a general principle that is to be met
Each guideline has checkpoints using which the conformance level (A, AA, AAA) of an accessible design is determined	Each principle has guidelines that clearly determine its conformance level (A, AA, AAA), thus allowing conformance levels to be met for each principle
Each checkpoint provides a general overview of the technique	Each principle provides a goal that it aims to meet
Each checkpoint provides a link to a page with specific techniques it can use	Each principle provides two links; one for better understanding the principle, and the other for techniques that it can use for achieving the principle
Each checkpoint provides a technology specific approach, such as HTML attributes, for solving an accessibility issue	Each principle takes a non-technical view at the accessibility issue in hand, and then provides the user with information on solving the issue

Table II.1: A comparison between WCAG 1.0 and WCAG 2.0 in their approach for representing the guidelines

Other types of web content accessibility guidelines are also available. They are listed in Appendix A.

II.1.2.2 The Authoring Tool Accessibility Guidelines

ATAG 1.0 (Treviranus, McCatherieNevile, Jacobs & Richards, 2000) provides guidelines for making authoring tools friendly to the overall accessibility situation. Version 1.0 of this guideline was published in 2000. It suggests that authoring tools should themselves be accessible, and they should promote and produce accessible web contents by default.

ATAG 2.0 is a working draft (W3C, 2006b), and is expected to be published in 2007. Macromedia DreamWeaver and Microsoft FrontPage are commonly used tools for authoring web contents. Content management systems (CMS) are alternatives to authoring tools that traditionally run on individual computers, and they provide the environment to author web pages directly from within a web site. Many web sites are built by embedding Macromedia Flash animations into HTML documents for providing an interactive user interface (Clark, 2004).

II.1.2.3 The User Agent Accessibility Guidelines

UAAG 1.0 (W3C, 2006c) provides the guidelines for making user agents that can help people access web contents effectively. This set of guidelines provides a comprehensive set of checkpoints that look into accessibility of web contents, users' control over rendering of the contents, users' control over the user interface, and recommendations for standard programming interfaces for compatibility with assistive technologies. Assistive technologies such as Bobby (Slatin & Rush, 2003) can understand the standard components of a web site and read the contents to blind users.

II.1.2.4 Other accessibility guidelines

Some other accessibility guidelines include XML accessibility guidelines (Dardailler, Palmer, & McCathieNevile, 2002), and the Accessibility features of SMIL (Koivunen & Jacobs, 1999), SVG (McCathieNevile, & Koivunen, 2000), and CSS (Jacobs & Brewer, 1999).

II.1.3 Accessibility validation tools

There are automated tools[2] such as RAMP, In-Focus (or InFocus), and A-Prompt (Lazar, Dudley-Sponaugle, & Greenidge, 2004), that can be used to check accessibility of web contents. These tools are old, and use WCAG 1.0. A-Checker is a new tool produced by Adaptive Technology Resource Center (ATRC) at the University of Toronto. It uses the working draft of WCAG 2.0 for validation of web contents, and can be used to verify that the content of a web site is accessible.

II.2 Goal Models and the NFR Framework

An approach to deal with the organization of design knowledge of web accessibility is by considering it as a non-functional requirement (NFR) (Chung et al., 2000). Just like there are functional requirements (FR) to a system[3], there are also requirements that are non-functional. The distinction between FR and NFR primarily lies in the way that they are considered in a design specification. While FR typically refers to what a system can do, NFR refers to how it is done (Cysneiros & Yu, 2003). That means, while FR refers to requirements that are stated explicitly, NFR refers to requirements that are stated rather qualitatively.

The problem that is encountered in requirements specification is primarily due to the representation of these requirements in modeling schemes. Since NFRs deal with quality requirements, they often contradict with other FRs and NFRs. Qualities of an information system may include NFRs such as security, usability, accessibility, interoperability,

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[2] O'Grady and Harrison (2003) offer a good overview of other accessibility evaluation tools and the basis on which the tools can be selected. Brajnik (2004) also provides some systematic approach in picking an appropriate tool.

[3] The term 'system' is used in here to represent any information system whether it is web based or not.

maintainability, scalability, and evolvability. These can be termed as the ‘abilities’ of an information system, where the abilities only refer the absolute vague idea of what they actually mean in terms of system development. What security may mean to a banking system may not be the same for a social web site (such as Facebook).

The NFR framework provides one with the ability to represent the implicitly defined quality requirements more explicitly. Using this technique, the explicitly defined system qualities can be analyzed for possible areas of conflicts.

Following are the important concepts for the goal oriented modeling technique. Figure II.5 is a sample representation of a graphical representation of system goals. The notation used in this technique is illustrated in appendix B part I.

Goal: The requirements specified by NFRs represent are considered as design goals. These goals are qualitative in nature, and thus help represent certain qualities that a system should achieve. They are often referred to as softgoals (Cysneiros, Yu & Leite, 2003) to represent their qualitative nature. Goals are achievable through alternative means, and so it allows a designer to make choices among such alternatives.

Goal graph: Goals are represented in a goal graph, where other goals also appear. Figure provides a sample goal graph. It allows for visualization of the goals of a system. Such graphs help in showing the relationships of goals among each other (Chung et al., 2000). Figure II.5 provides a simple example of a goal graph.

Contribution links: Goals graphs allow goals to be represented in a way so that their relationships can be analyzed. System goals can often be conflicting or complementary to each other (Chung et al., 2000). Such contributions can be presented in the goal graphs using HELP link (representing complementary goals) and HURT links (representing conflicting goals) between the related goals.

Goal refinement: A goal is something that can be achieved in multiple ways. To achieve a goal, one may have to do multiple things, and may also have to achieve other more specific goals (Chung et al., 2000). Thus, it is necessary to see how a goal can be refined into more specific ones for achieving its purpose. This can be done by refining a goal using links such as AND, OR, and MAKE links. Figure II.5 illustrates refinement of the top goal using such links.

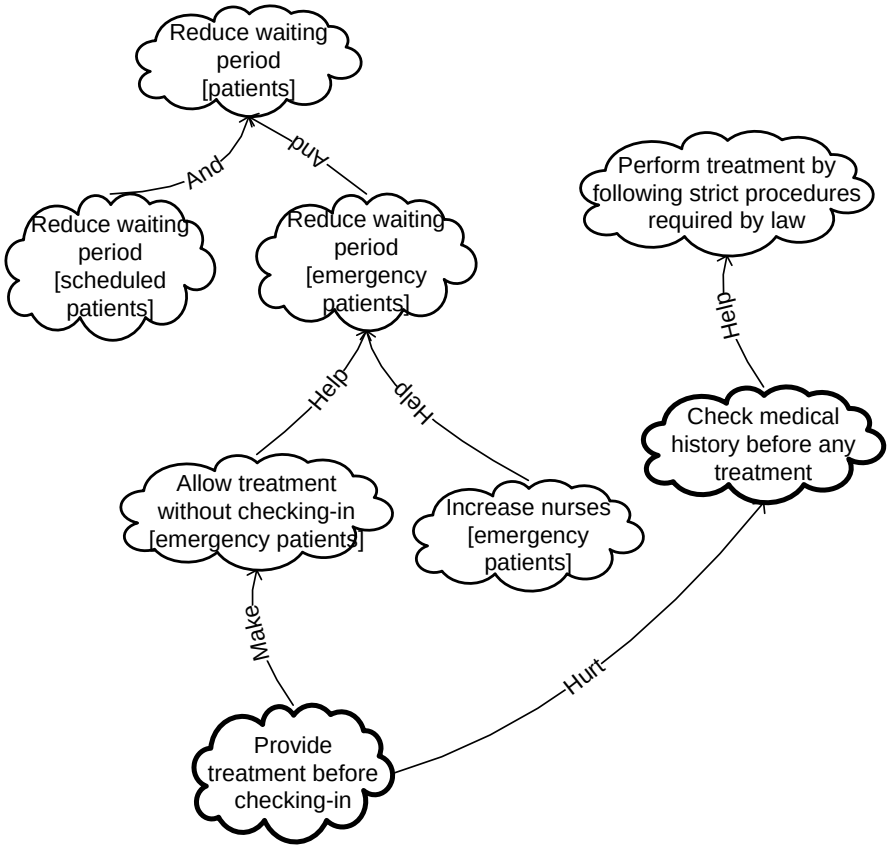

Figure II.5: A simple goal graph

Goal operationalization: In the NFR graph in figure II.5, two types of clouds are used. The thin lined clouds refer to the goals that have not been sufficiently decomposed as there may still be different ways of achieving it. However, the thick lined clouds refer to goals that have been dealt with sufficiently, and the knowledge in such NFRs can be used

in the development of the system. This level of decomposition of NFRs is known as its operationalization (Chung et al., 2000).

Goal satisficing: Note that the term used here is ‘satisficed’, and not ‘satisfied’. Chung et al. (2000) mention that it is rarely possible to fully satisfy an NFR, since many NFRs are only qualitatively achievable. Since qualities are subjective and they conflict with other quality requirements, some of the qualities may only be dealt with to some degree. By satisficing a goal, it is meant that the goal has been sufficiently evaluated and dealt with in the known context. A goal must be satisficed in a way that it does not conflict with other satisficed goals.

Goal evaluation: Since a goal cannot be satisficed if it is in conflict with other satisficed goals, it must be appropriately evaluated against other goals. Evaluation of a goal allows for evaluation and prioritization of related goals, and propagation of the goal evaluation. Propagation of the goal evaluation is a technique where evaluation of the goals is propagated across the goal graphs to check whether the original goals have been dealt with sufficiently.

Let us consider an example. Assume that two goals, A and B, are in conflict with one another. It may not be possible for goal one to achieve A and B together without looking for alternative means. Through alternative means, it may be possible for both A and B to be satisficed. However, if no alternatives remain, the designer has to prioritize on which goal to satisfice and which one not to. Moreover, prioritization of the goals can be done using the goal graphs by analyzing which goal has more impact in the system and helps achieve other system goals. The goal evaluation technique allows one not only to evaluate the operationalized goals, but also allows the designer to propagate the evaluation across the goal graph. For example, if goal A decomposes into goal B and C using AND decomposition links, it means that both B and C must be satisficed to achieve goal A.

In figure II.5, the goal of reducing waiting period of patients decomposes into two goals using AND decomposition links. These goals are reducing waiting period of scheduled patients and reducing waiting period of emergency patients. Using goal evaluation technique, the designer has to make sure that both the decompositions are satisficed before s/he can satisfice the top goal. Please refer to Chung et al. (2000) and the Masters thesis of Horkoff (2006) for more details on the goal evaluation technique.

Goal types and topics: Goals can be decomposed into other goals. Such decomposition can happen by type and topic (Chung et al., 2000). Type refers to the kind of ability that is in discussion. Topic refers to the subject matter, which the quality is being described for. Decompositions may take place in different ways depending on the situation.

NFR graphs can thus help model the requirements in a manner that can represent the following design knowledge (Gross & Yu, 2001).

- *Requirements as design goals*: This is achieved through the use of the goal graphs to represent different functional and non-functional requirements. Analyzing such goals collectively can reveal alternatives that are important for a design process.
- *Relationships among the goals*: The interaction among different goals that show how one goal may positively or negatively contribute to other goals.
- *Implicit or intermediate goals*: New goals can be identified through interaction of different goals. Such new goals can be incorporated into the NFR graphs for a more appropriate analysis.
- *Decompose using type and topic in goals*: Goal decomposition using type and topic can help see the different ways in which the goals can be viewed. This can be seen as a refinement process, where the decomposition is a step closer to our understanding of the overall goal.
- *Reasoning for solution achieved*: It can show how a solution is reached via reasoning depicted in the NFR graphs. Goal decomposition (by type and topic), their interaction, and their operationalizations can help provide the reasoning.

- *Unintended correlation among goals and solutions*: Unintended side effects can be identified through goal interaction among goals that were previously not thought to have any impact on other goals.
- *Analyze the alternative solutions*: Different alternatives can have different ways of achieving the goals. Alternatives can have different correlations with other goals. Such correlations can be used to analyze the impact of one alternative over the other.
- *Qualitative reasoning for goal achievement*: Starting from the most refined nodes, the goals can be evaluated as to how well it has been achieved. Through evaluation of more specific goals, the more abstract goals can be evaluated.
- *Elaboration of design goals*: NFR graphs allow design goals to be elaborated through goal decomposition and subsequent operationalization.

II.3 Design patterns

It is unusual for designers to reinvent the solution to a particular problem that they deal with on a regular basis. While there are problems that are particular to specific cases, there are also problems that appear in similar ways under different circumstances. In such cases, there are patterns of problems that can be kept by the designers who can design a solution to it with a design pattern. Design patterns can describe a commonly recurring solution to a general design problem in a particular context (Buschmann et al., 1996).

Design patterns can be represented in many forms as long as they discuss the context, the problem, and the solution to the problem. A commonly cited work is by Gamma et al. (1995), who describes Gang-of-Four (GoF). This work describes reusable solutions to recurring problems in software design. GoF has been utilized and extended for usage with Object-Oriented designs[4] and human-computer interaction designs[5].

[4] See the work of Mak, Choy, and Lun (2004) for an example of incorporating design patterns in UML.

Since design patterns deal with problems in different contexts, the solution provided by a particular pattern may affect the solution of another related problem. To deal with these, design patterns can fall into families of similar problems (Buschmann et al., 1996), where the solutions to the patterns can express design problems that affect each other. For this reason, patterns can appear in relationships with other patterns that they help resolve their problems, and also the patterns that they are at conflict with. These interdependencies can be classified and categorized for better organization when there are many patterns that exist in the pattern system[6].

Pattern relationships can be used for organizing patterns. They can be represented graphically (Gamma et al., 1995) to show a general pattern system. A sample pattern graph is shown in figure II.6. The rectangular boxes represent each pattern, and the arrows show the pattern's relationship with another pattern. This pattern system is a relatively simple one. There can be more complex patterns that can have many more relationships with other patterns within the pattern system.

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[5] See the work of Teuber and Forbig (2004) for an example of incorporating design patterns in human-computer interaction design.

[6] A pattern system is an organized structure, where the constituent patterns are tied together into a system of patterns (Buschmann, 1996).

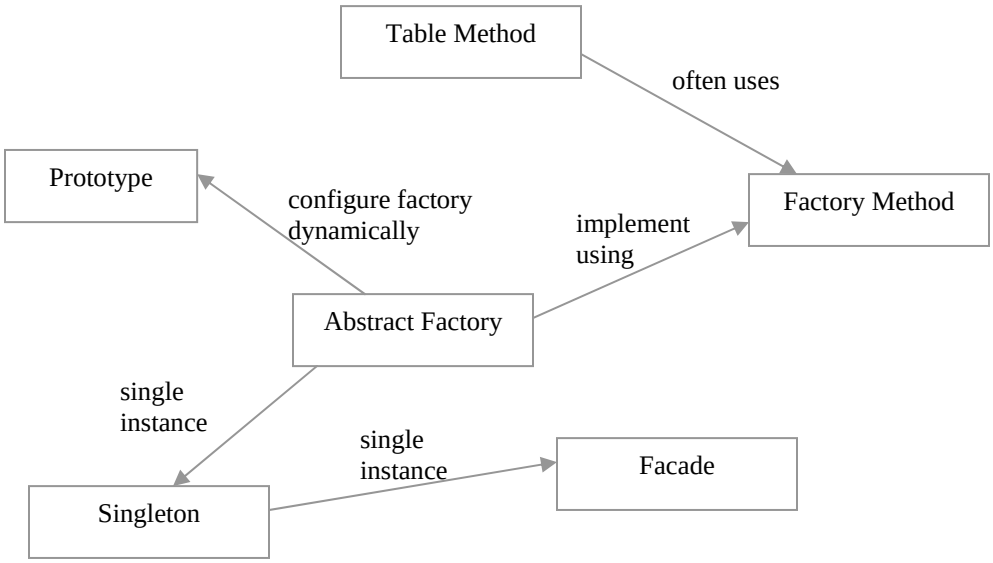

Figure II.6: A graphical representation of design pattern relationships (Gamma et al., 1995, 12)

Design patterns may be expressed by clearly stating the context, the problem, and the solution to the problem (Buschmann et al., 1996). Along with these three components, a fourth component can also be added (Teuber & Forbig, 2004) that deal with the 'forces' which has led the design pattern to solve the problem in a manner that it does. In this component, goals and qualities (such as availability to mobile disabled users, conformity to business objective of textual components, etc) of the design pattern may be mentioned. Using these can help in forming knowledge of solutions to design problems in certain contexts.

Patterns may not be static, and they may become outdated with additional patterns being added to the system. Their descriptions may change over time. Updating a pattern description may cause the pattern to have more associations with other patterns within the system, and new relationships may arise while old relationships may not hold true anymore (Buschmann, 1996). This is also true for new patterns being added to the pattern system (Buschmann, 1996).

Chapter III: The Approach

I shall now describe the approach that I have taken in this research. To do that, it is first necessary to provide a critique of the accessibility guidelines which will surface issues around their representation and application. Following that, I shall describe the possible ways that the goal models and the design patterns can help solve the problems that have surfaced during the critique of the accessibility guidelines.

III.1 Shortcomings of the accessibility guidelines and their usage

Even though much work has been done on accessibility research, it is still remains a vaguely enquired area as to why the guidelines have not yet been able to make an impact in the web design community.

III.1.1 Ambiguity in interpretation of guidelines

One of the major problems of any of such guidelines, as Paddison and Englefield (2004) indicate, is the ambiguity that lies in the qualitative representation of the guidelines. Since guidelines often make use of terms such as ‘appropriately’, ‘equivalency’, and ‘relativity’, it is often difficult to make such terms explicit to achieve quality use of the guidelines. Research indicates that this problem is being reported by many others, including Lazar et. al. (2004), and Hanson et al. (2005). It leaves designers to ponder the question as to how appropriate does something need to be appropriate.

The difficulty in comprehending the qualitative terms in the guidelines become apparent when the case of using alternative texts for images is considered. Assume that a designer

has used spacer images[7] in his/her design and names each one of them "spacer" or "space1ccceee.jpg" (reflecting the name of the image). According to WCAG 1.0, all images need to be appropriately[8] described in the alternative text. Based on UAAG recommendations, a screen reader software will generally read the image name to the user when an alternative text is missing. However, combining these two guidelines, it is difficult for a designer to determine what WCAG 1.0 means by "appropriately" in this context. It turns out that the solution to this problem (provided by many researchers) is to use a blank alternative text. The blank alternative text represents a null value (Clark, 2003; Thatcher, 2002), which screen reading software are not going to read out to the user. Although WCAG 2.0 is more detailed in considering such cases, it is still necessary to point out that situations like these do come up, and the guidelines are unable to provide with effective help in such cases.

III.1.2 Web designers not making full use of guidelines

According to the Web Accessibility Integration Model (WAIM) (Lazar, Dudley-Sponaugle & Greenidge, 2004), there may be three reasons for the increasing inaccessibility of web pages. WAIM considers web accessibility from three aspects. They are[9] the social foundation, stakeholder perception, and the web development process.

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[7] Some web designers rely on images in their web design, where the images are solely used for creating appropriate spaces for the desired presentation of the web page contents.

[8] The term 'appropriately' is the emphasis here. The question that can be raised here, as I shall discuss in the following, is how appropriate does something need to be for being appropriate enough. Do the three levels of checkmarks in WCAG 1.0 (priority 1, 2, and 3) means three levels of appropriateness? It actually does mean three levels of appropriateness, since the three priority levels mean three levels of accessibility. However, the appropriateness of an alternative text is referred to the suitability of the alternative text in relation to the component it is describing.

[9] The first is social foundation, which looks at how the society looks at disability and the importance they give. Second is the stakeholder perception, which suggests that it depends on the web developer knowledge and the knowledge of the client. Third is the web development process, which includes guidelines and tools, initial sited design, and the management and redesign of the web site.

Societal foundation about accessibility is under serious consideration at government level in many countries around the world. Barriers to receiving free information may fall under government discrimination acts such as the Disability Discrimination Act (DDA) in the UK (Hackett, Parmanto, & Zeng, 2005), Americans with Disabilities Act (Johnson & Ruppert, 2002) in the US, and the Australian Disability Discrimination Legislation (Wallis, 2005) in Australia. Based on such substantial governmental support, it can be safely said that the laws for discrimination against disability exist due to the societal view that such discrimination is inappropriate and wrong.

For stakeholder perception, it can be argued that an economic benefit that generates more revenues (by providing access to their products to all user profiles) may be the driving force into creating their commercial site accessible. Consider the case of Amazon. In 2002/2003, Amazon had advertised the launch of an accessible web site. It was soon found[10] that the primary motive of their move towards an accessible web site was due to generating more revenues by making their web site contents available to mobile devices (Slatin & Rush, 2003). Nevertheless, the improved site with accessibility features has successfully made itself available to the 400,000 visually disabled Americans too (Lazar, Beere, Greenidge, & Nagappa, 2003).

The third aspect in WAIM involves the web development process. In a study of 50 Mid-Atlantic US web sites (Lazar et al., 2003) in 2002, 49 of them revealed violations of accessibility guidelines. Notably, the worst accessibility issues have been found in web sites for organizations in web development and information technology field (Lazar et al., 2003). When Lazar and Greenidge (2006) have been back to the same sites for a follow-up study a year later, the only accessibility issue that has improved from the 2002 study is the presence of alternative texts for images. Otherwise, all other accessibility issues have deteriorated. And this time, the web development organizations seemed to have further

[10] In a research conducted by Slatin and Rush (2003) on Amazon's web site, it was found that the Amazon web pages contained meta tags describing the site to be friendly to mobile devices. The cited book describes this in detail.

increase in accessibility issues than the study done in 2002. This has led Lazar and Greenidge (2006) to argue that there is an increasing lack of technical knowledge in accessibility guidelines for the web developers in web development organizations.

As mentioned earlier, there is sufficient push by governments and profit-making organizations towards creating accessible web sites. However, there is little understanding within the research community for whether web developers involved in designing accessible web sites actually make sufficient use of the guidelines that are available to them. And based on the literature available at the time of this research, it seems plausible that the web designers are not making appropriate use of the web accessibility guidelines to their full potential.

III.1.3 Difficulty in dealing with textual representations

The accessibility guidelines are textual representations, organized using a given criteria. As noted earlier, the organization of WCAG 1.0 is based on the techniques, while in the case of WCAG 2.0 it is based on the principles. To add to that, there are complaints by many researchers that these guidelines are lengthy (Thatcher, 2002; Lazar et. al., 2004) and potentially require great time investments in understanding the issues and problems.

Since the guidelines are textually represented, a major problem that can be faced is how the guidelines can be applied in making web designs. It requires narrative understanding of the guidelines, and the designers are left with no given technique to apply the guidelines systematically. Rather, the designers have to find their own way for integrating the guidelines in their designs.

III.1.4 The guidelines are too generic

Accessibility guidelines are quite generic in assuming their concerns about accessibility. Referring back to guideline 4 of WCAG 1.0 and principle 3 of WCAG 2.0 discussed earlier, there seems to be very little guidance provided to the web developers for which accessibility guidelines are intended to help what type of disability. The target audience of a web site may play a major role in the development of the web site. In a study (Kelly, Phipps, & Swift, 2004) on the application of accessibility guidelines on an eLearning system, it was found that using WCAG 1.0 may come into a conflict of interest when a blind student is going to take a web based exam. To cite the specific example used in this paper, if a student is being tested by showing an image and the student's understanding about the subject matter presented in the image, it may not be appropriate for the image to include an alternative text to describe it. Thus, the conflict remains between the goals of providing accessibility features and the goal of testing a student.

Kelly et al. (2004) have argued that even though WAI has successfully brought the issues with accessibility under scrutiny, they have not been able to provide the best way to approach this. In their paper, they have suggested the use of a holistic approach where accessibility is considered as a feature that needs to be properly analyzed with other needs, such as the needs of the users, local factors, usability issues, user experiential outcomes, and finally the quality assurance for the system in place. Figure III.1 shows the proposed model by Kelly et al (2004).

III.1.5 No given technique for application

In the study by Lazar and Greenidge (2006), they have found that the web development organizations seemed to have increasing accessibility issues. Web development organizations build web sites on a contractual basis, and they may deal with multiple types of web sites from different domains offered to multiple types of audiences. Thus, designing web sites for different types of domains and for different types of audiences may require that the guidelines are applied differently, based on the situation. The study by Kelly et al. (2004) noted in the previous section indicates an aspect of this very issue.

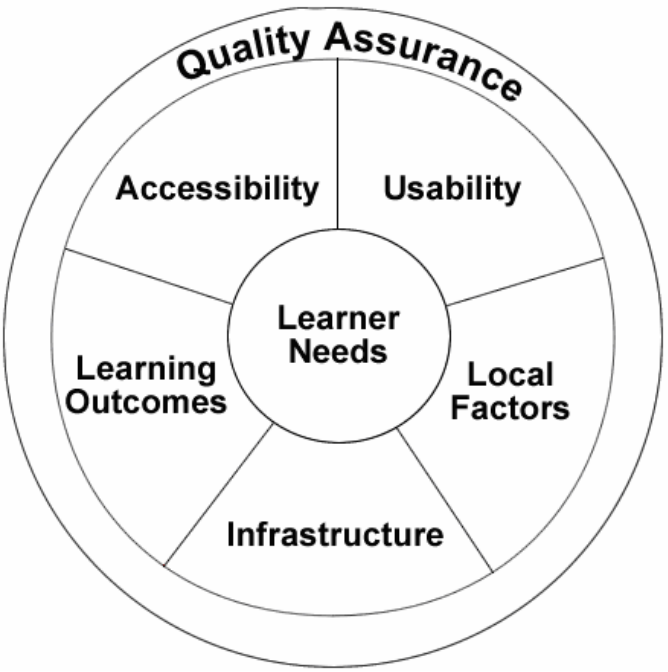

Figure III.1: The model depicting a holistic approach proposed by Kelly et al. (2004)

Given the situation that the accessibility guidelines need to be applied by the web designers in different scenarios and for different target audience, the need of a reference model becomes apparent. Given that guidelines such as WCAG 1.0 and WCAG 2.0 are long textual documents, it may be difficult for designers to use these guidelines as quick references. There is a requirement of time investment that the designers must keep in mind when they use the guidelines. Depending on a web development project, a designer may not have enough time to spend on meticulously reading through the accessibility guidelines. Without proper time investment, it is difficult for anyone to be able to use the available guidelines appropriately.

III.1.6 Difficult to determine conflicting requirements

As it has been pointed out earlier, users with different types of disabilities require different mechanisms to support their usage of web pages. Requirements for different disabled users may conflict with one another. Pertaining to this notion of conflicting requirements, it is almost impossible to provide a solution that will meet the requirements of all types of disabilities. Thus, for designers to make quality use of accessibility guidelines, they need to be able to choose the type of qualities they need to satisfy for making their web pages accessible to their selected target audience. However, none of the accessibility guidelines tell the designers which qualities to satisfy for a given target audience. Rather, there is a vague mention about the types of disabilities that a specific guideline[11] may help serve. In fact, most of the accessibility guidelines refer to accessibility as a generic term that can help the disabled users in general.

III.1.7 Lack of alternative solutions

Further to the problem of disability specific accessibility, very rarely do the guidelines provide alternative solutions to certain accessibility issues. For example, in the sample guideline provided in figure II.3, the checkpoints are not alternative ways of achieving accessibility, but are different levels of accessibility that can be achieved if the checkpoints are followed sequentially. Similarly, the guidelines provided in figure II.4 are merely principles that must be satisfied, but the alternatives are not provided for application based on the merit of the situation.

When there are conflicting requirements for users with different types of disabilities, alternative solutions may allow a designer to evaluate alternative approaches in trying to accommodate multiple disabled users with conflicting requirements.

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[11] This can be seen in WCAG 1.0. For example, for guideline 1 (provide equivalent alternatives to auditory and visual content) there is a mention about raw text for synthesized speech, which can help blind users use screen readers, and deaf users to visually benefit from the text. However, raw text can also be useful to motor disabled users, who cannot scroll through the web pages for getting to their content. These users may rely on screen readers to read out the page contents to them.

The challenge of creating web sites with specific target audience may face yet another difficulty along the road when there is a change in target audience, and the web site now needs to provide a design that would allow the modified target audience to be able to access the web site content. The difficulty here involves understanding the new requirements for the modified target audience. In other words, there is very little guidance for providing variability with changing user groups in using the guidelines.

III.2 Using Goal Graphs for organizing accessibility design knowledge

Looking at the issues around web accessibility, the web accessibility guidelines and the shortcomings of the guidelines, a few questions arise. Since many of the arguments raised about accessibility guidelines refer to how the guidelines are organized to provide suitable help to the designers in making design decisions, the question that arises is, whether there is a better way of organizing such knowledge into a format that can be easily used by the designers. Can the guidelines be organized in a way that will allow them to be applied more systematically? Can the guidelines help a designer make choices on its application based on the target audience and the usage environment? Is it possible for designers to choose from alternative solutions to feature on accessible web designs?

III.2.1 A simple case

To see how goal oriented modeling can be used in accessibility research, let us consider a sample representation of a possible guideline. Figure III.2 shows an example of a goal

graph which deals with visibility as a quality requirement for web page components. Note that this example is only for demonstration purposes only; the graph is developed from a very general understanding of the current guidelines. Chapter VI of this paper demonstrates a step-by-step process for developing the goal graphs from the guidelines.

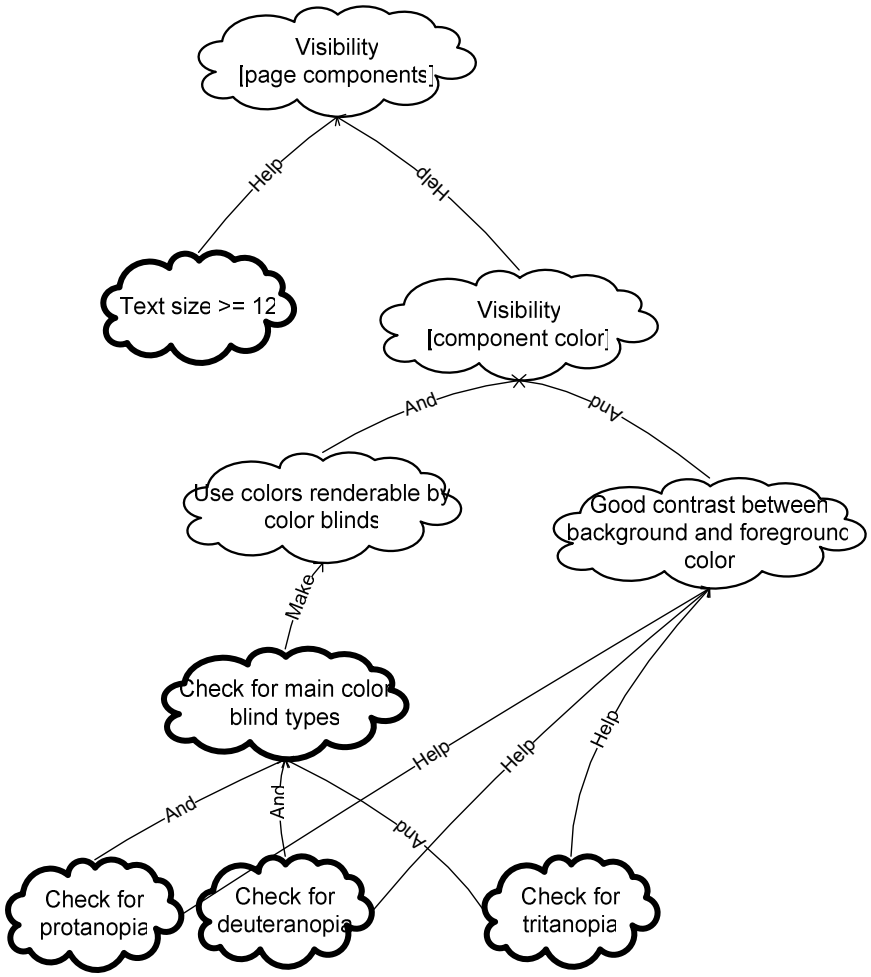

Figure III.2: An NFR network dealing with visibility (type) of page components (topic)

Figure III.2 shows how visibility can be helped by using text size as greater than or equal to twelve. However, this network further shows that only making text size larger is not going to help, but that it requires the web page component colors to be visible as well. The approach that is used to organize such design knowledge in a goal graph is discussed in the following.

III.2.2 Applying the concepts from NFR framework

In section II.2, I have discussed the main concepts of the NFR framework. Here, I shall demonstrate how the concepts from the NFR framework fit in organizing accessibility guidelines.

Use of goals: As it is seen in figure III.2, visibility is a goal, which needs to be achieved for providing accessibility. The same applies for other issues that need to be resolved for providing accessibility. For example, navigability, understandability, and renderability are all goals, and they are all potential candidates for solving accessibility issues.

Use of goal graphs: Earlier in this chapter, I have argued that since accessibility guidelines are textual representations, their usage require thorough understanding of the natural language in which the guideline is represented. Using goal graphs as demonstrated in figure II.2, such design knowledge can be represented graphically.

Use of contribution links: There are two goals that help achieve the top goal (visibility of page components). These two goals are connected to the top goal using HELP links. Furthermore, the goals for checking the three types of color blindness all help achieve the goal of maintaining an appropriate level of color contrast between the background and foreground colors of web page components. Thus, they are all connected with the goal of good color contrast between background and foreground color using HELP links as well.

Use of the goal refinement technique: As mentioned earlier in section II.2, goals can be refined to see how more specific goals can be used in achieving a bigger goal. This is apparent in figure III.2 where the goal of checking for main color blind types can be achieved by achieving the three goals connected to it using the AND links. This makes it easier for the user of this model to see that all three goals (checking for protanopia,

deuteranopia, and tritanopia[12]) need to be achieved to fully achieve the goal of checking for color blind users.

Use of the goal operationalization technique: The accessibility guidelines are intended to demonstrate to the designers on how to solve an accessibility issue by providing a technique that can be used in solving the accessibility issue. In this case, the operationalized goals can be used for representing the necessary techniques. For example, "text size greater than or equal to twelve" can be used as a necessary requirement in designing a web site. It leaves no ambiguity for the designer in using the operationalized component of the model.

Use of the goal evaluation and goal satisficing techniques: To check whether an accessibility goal has been achieved, the goal evaluation technique can be used. Consider the eLearning case discussed by Kelly et al. (2004) where the goal of providing a textual alternative to an image conflicted with the goal of examining a student. Using this technique, such scenarios can be systematically evaluated to check whether the goal does not conflict with other goals of the system. Through systematic evaluation, a designer can also check which goal can be satisficed, and which can be denied.

Use of goal types and topics: In the goal graph in diagram III.2, notice the way some types of goals decompose into other types. Utilizing the goal decomposition technique using the goal's type and topic, important knowledge about the guidelines can be conveyed to a designer. For example, visibility of the color of a component on the web

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[12] There are multiple ways of simulating the color of a computerized component that are used in the design community. One of such simulators is the Colour Blindness Simulator provided by Etre (2007). This tool allows users to upload an image, which is run through its color simulating function, and a simulated version of the image is provided for a chosen type of color blindness. This tool currently supports the three common types of color blindness, named protanopia, deuteranopia, and tritanopia.
An alternative tool is the Accessibility Color Wheel (Mazzocato, n.d.), which provides a color wheel where a user can hover the mouse on. An algorithm calculates the color on which the mouse is hovered on, and the tool automatically tells a user whether the chosen color is appropriately viewable to the color blind users.

site may need to decompose into colors that are renderable to color-blind users, and colors that contrast with each other for better visibility. Furthermore, WCAG 2.0 is a principle-oriented guideline. Thus, this technique can help in representing WCAG 2.0's principles based on the type of the principle (such as understandability and navigability) and topic of the principle (such as users with visual impairment or with mobility disorder).

III.2.3 Understanding a goal graph

Let us consider the NFR graph in figure III.3, where accessibility is used as a design goal. It is mentioned in the top node as accessibility of web page contents. The following node in the graph considers accessibility of web page contents in three ways. They are navigability of web pages, understandability of web contents, and renderability of the web page contents. As mentioned earlier, this is known as decomposition by the type of NFR in consideration (marked with dotted lines in the area A). In this context, the decomposition is done using AND nodes, which mean that to achieve accessibility, all three decompositions of the NFR must be satisficed to sufficiently satisfice accessibility of web page contents.

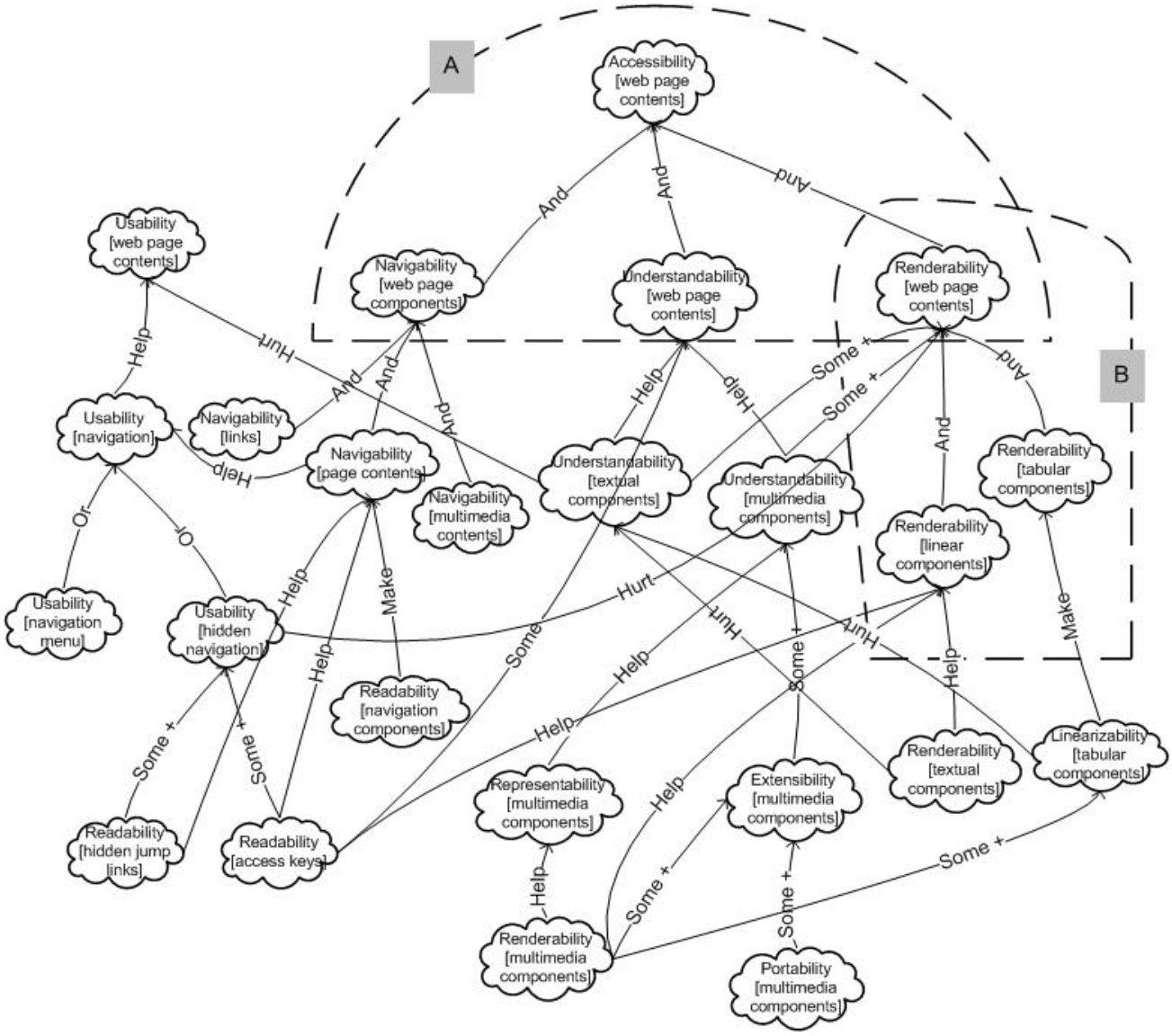


Figure III.3: An NFR graph depicting design goals for accessibility

Figure III.3 has a goal that represents renderability of web page components, which decomposes into two goals – renderability of linear components, and renderability of tabular components. This is not the same way that the goals in area A have been decomposed. This is decomposed based on the topic of the goal, and so is known as decomposition by topic (marked with dotted lines in area B).

In figure III.3, notice the use of usability of web page contents within the context of accessibility of the web page contents. It is a brief analysis which shows how different

mechanisms of achieving accessibility can have an impact on usability of the web page. It indicates that specific system goals can be incorporated in this way to evaluate and prioritize the goals appropriately. This NFR graph does not however take the decomposed graphs to a level where they can be operationalized. It is one of the concerns for the proposed research to identify an optimum level of decomposition which an NFR graph should reach, since the graph can easily become too large. An operationalized version of this graph can presumably be used by designers as a reference for creating accessible web pages.

III.3 Using design patterns for accessibility

The use of goal graphs demonstrated in section III.2 allows us to convert the textual representations of the accessibility guidelines into a graphical representation. Using the goal graphs, design knowledge for accessibility purposes can be applied in designing accessible web contents. However, each node within the goal graph can only hold small amount of text. Since the accessibility guidelines need to provide technical assistance to the web designers as a solution to the accessibility issues, such technical details need to be kept separate from the goal graphs and referenced to from the goal graphs appropriately. For this purpose, I am introducing the use of design patterns in addition to the goal graphs.

I shall demonstrate the use of the design pattern using an example of a common recurring problem in making accessible web contents which involves presentation of textual information in a way so that screen readers can understand it. Note that this is for demonstration purposes only, and that it may not be related to an actual accessibility guideline.

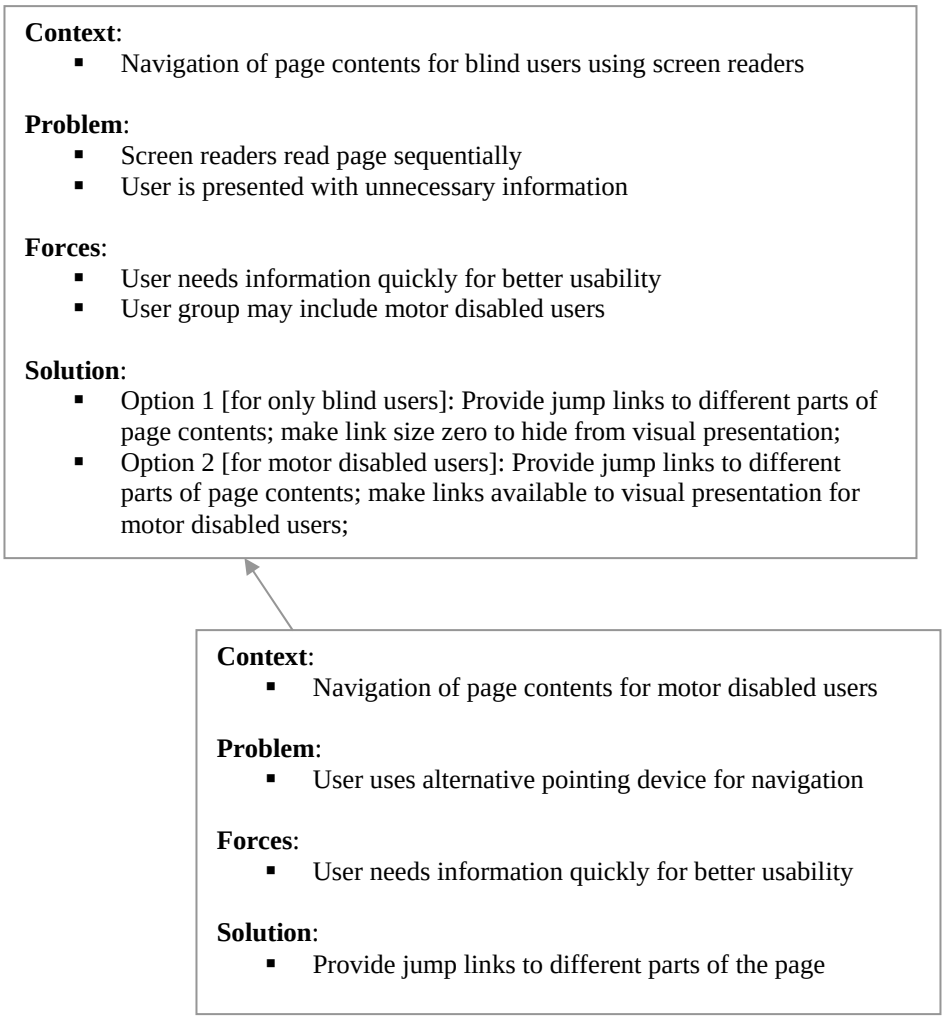


Figure III.4: Representation of two design patterns in a relationship

Considering that a screen reader reads the page contents sequentially, there may be a lot of unrelated texts that a screen reader may read to the user. Jump links in HTML can be used in such a case (Hull, 2004), where screen readers may give options to the users to jump to different sections of the web page (such as body, menu, references). Designers may hide the jump links from users that can view the page by setting the text sizes for such links as zero. However, hiding the jump links may make the page inaccessible to motor disabled users who may utilize the links to navigate from section to section (Hull, 2004). Representing these in the same design pattern may not be possible. However, these design problems can be represented in design patterns by linking them with each other whenever there is a need to. This is shown in the figure III.4.

Using the patterns, details about the design knowledge can be separated from the goal graphs. This separation of the details from the goal representation allows accessibility goals to be represented in a graphical format.

III.4 General overview of the approach

Accessibility is a quality requirement, and representation of quality requirements need to be done more explicitly for being used in any design process. Thus, this research looks at the use of the goal graphs to bring the accessibility requirements closer to the design process, while keeping the details of the design knowledge separate from the goal graphs.

In the following sections, I shall provide a brief overview of the proposed approach. First, I shall discuss how the guidelines shall be reorganized and represented using the goal graphs and design patterns. I shall then discuss general techniques for applying the reorganized guidelines through systematic analysis and using the reorganized guidelines for performing accessibility evaluations. Finally, I shall discuss the notations that I propose to use for applying the reorganized guidelines.

III.4.1 Reorganization and representation of the accessibility guidelines

For using goal oriented techniques in representing the guidelines, the guidelines first need to be reorganized and represented using the proposed technique. By keeping in mind the concerns raised by the web designers in the consultations, the reorganization process is going to take the following steps. Note that these steps are to be performed in sequence.

Step 1: Deconstruct a guideline to check

a. the goal for the guideline
b. the decompositions of the goal (how different techniques are put together to achieve the goal)
c. the type and topic by which decomposition is being done
d. the contributions that the goals make to other goals
e. the operationalizations of the goal

Step 2: Form design patterns by

a. separating the technical details after operationalization
b. numbering the pattern in a systematic manner using the guideline or technique number

Step 3: Link the pattern to the goal graphs by

a. using the pattern number to link the pattern to the goal graph

III.4.2 Application of the reorganized guidelines

Application of the guidelines can be of two types. First, the guidelines can be used for solving accessibility issues of a user interface (UI). This involves not only application of the guidelines, but also application of any other related goals for the system. Second, the guidelines can be used in evaluating a UI. Like the other application, this evaluation technique can also involve detailed evaluation using other goals for the system.

Both types of application of the reorganized guidelines follow a similar mechanism. Following is the step-by-step process that involves application of the reorganized guidelines.

Step 1: Perform goal analysis by

a. bringing in the related accessibility goal graph and the system goal graphs together
b. checking for any positive or negative contribution the goals might have on other goals (for example, using HELP and HURT links)

Step 2: Apply the analyzed goals by

a. bringing the UI design next to the analyzed goals
b. [in the case of applying guidelines into a UI design]
    a. indicating which accessibility goal applies to which UI component
    b. indicating which accessibility goal is unable to be applied to which UI component
c. [in the case of evaluating a UI design]
    a. indicating which UI component is in conformance to which accessibility goal
    b. indicating which UI component is in violation of which accessibility goal

Step 3: Evaluate the application to check whether the goal has been achieved by

a. satisficing the goals that could be or have been applied into the UI design
b. denying the goals that could not be or have not been applied into the UI design
c. propagating the evaluation to check how the original goal has been achieved

III.4.3 Notations for application of guidelines

Generally speaking, there are two types of goals that can be identified from the usage of the goal graphs in the proposed way. First, the conventional goal notation (see appendix B part I) is used for creating the goal graphs. Second, the goals that reference design patters (for directing designers to the design patters for technical deals) are shown using a different form of notation than the conventional goal notation. In this case, a set of

opening and closing curly braces have been used for explicitly indicating the referenced design pattern. This is indicated in figure III.5.

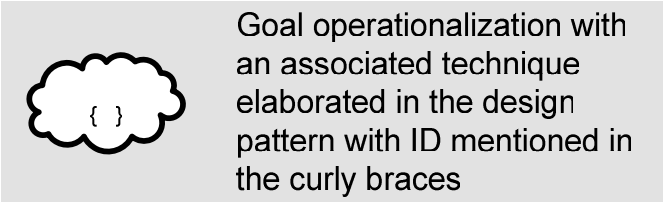


Figure III.5: Notation used for goals that reference a design pattern.

For applying the reorganized accessibility guidelines, the original notations of the goal oriented modeling technique may not be sufficient and/or suitable. Thus, I propose the use of the following additional notations. The four notations are also shown in figure III.6.

- APPLIES TO link: This link is going to point from an accessibility goal to a particular interface item indicating that the goal applies to and is able to provide an accessible solution for the item. This is intended for applying the accessibility guidelines to an interface design (rather than performing an accessibility evaluation).
- UNABLE link: This link is going to point from an accessibility goal to a particular interface item indicating that the goal is unable to be applied to provide an accessible solution for the item. This might happen when a guideline cannot meet the requirements imposed by external factors (such as another goal in the system that this goal has an impact on).
- CONFORMS TO link: This link is going to point from a UI component to a particular accessibility goal indicating that the component is in conformance of the goal.
- VIOLATES link: This link is going to point from a UI component to a particular accessibility goal indicating that the component is in violation of the goal.

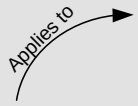
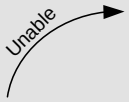
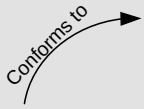
APPLIES TO link		Applies to link, indicating that an accessibility goal from the graph applies to a certain component
UNABLE link		Unable link, indicating that an accessibility goal is unable to be applied to a certain component and requires further analysis
CONFORMS TO link		Conforms to link, indicating that a component conforms to the specific accessibility guideline
VIOLATES link		Violates link, indicating that a component violates a specific accessibility guideline

Figure III.6: The notations used for applying the reorganized guidelines

A complete list of notations used for the conventional goal oriented modeling is provided in appendix B, part I. The list of notations used for this research (including the conventional goal oriented modeling notations) is provided in appendix B, part II.

Chapter IV: Methodology

IV.1 Research design

The research is a qualitative one that evaluates and establishes a platform in which web accessibility guidelines are represented using goal graphs and design patterns. This approach at organizing the guidelines is aimed at making it easy for web designers to use the guidelines in their designs for accessible web sites.

The research has been conducted in three steps. The first step was originally intended to involve a task analysis of web site designers to find out the challenges that they face in incorporating accessibility guidelines into their designs. However, the actual study has replaced this with an analysis of the possible ways that a designer may use the guidelines. This has been done in order to get a better understanding on the difficulties that the designers may face in applying the guidelines. In the second step, a goal oriented modeling technique has been used in order to change the representation of the accessibility guidelines from their textual format to a combination of graphical and textual format. Finally, in the third step of this research, the analysis from the first section part of the study has been used to analyze the way that the reorganized guidelines can be applied into performing accessible web designs. This part of the study has also analyzed other possible ways in which the reorganized guidelines can be applied.

IV.2 Data collection and sampling

The study attempts to amalgamate the knowledge from three different sources in order to help propose the reorganization of the accessibility guidelines. The three sources of knowledge are web designers (from their experiences in using accessibility guidelines), researchers (from their researches that make well-founded claims), and the web accessibility guidelines themselves. The approaches taken for gathering the knowledge in this research are provided in the following.

IV.2.1 Web designers

The work practice of different individuals involved with similar work responsibilities can vary significantly. This has been seen in many research materials[13] that have been consulted for the study, where the authors have reported their difference in views about the use of web accessibility guidelines, and also their approaches to work around the difficulties that they face in using these guidelines. Such approaches in using the guidelines are significant for this research. This will help reveal the specific challenges that are faced by the web designers in using the guidelines which will

The approaches used by the web designers in using accessibility guidelines are purely their tacit knowledge that they utilize to overcome the challenges that are faced. To gain a greater level of understanding of such challenges, six web designers have been consulted. The consultations have involved an hour of open ended discussions on a one-on-one meeting. The main discussions have focused on how the designers apply the accessibility guidelines in the everyday work and how they evaluate their designs to check for guideline conformance.

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[13] This is evident due to the different reactions in using web accessibility guidelines by authors such as Clark (2003), Thatcher (2002), Slatin and Rush (2003), and Wallis (2005).

Out of six consultations, two have been recruited by sending a mass email message within the Adaptive Technology Resources Center (ATRC)[14] at the University of Toronto. Two participants have been found through an online cricket (sports) forum which maintains a superior accessibility guidelines conformance. The two individuals are directly involved in maintaining the web site for the cricket forum. Finally, the other two participants have been found through personal contacts.

The participants have received no financial compensation for participating in this research.

IV.2.2 Expert knowledge in publications

Researching journals databases such as Scholars Portal and ACM Digital Library have yielded some key resources that have been used for extracting knowledge for the research. Searching the library catalogue of the University of Toronto Libraries (UTL) and York University Library (YUL) have yielded a few key resources in book format that have been published in relation to accessibility research. Furthermore, searching Google Scholar has generated many more articles (from journals and elsewhere) that are written by individuals with deep understanding about issues surrounding web accessibility and the usage of different web accessibility guidelines.

All the resources used in gathering knowledge in this research have been used by strictly following the copyright limits imposed by the authors. None of the resources required formal permission from their authors before they could be used for research.

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[14] I would like to thank Jutta Treviranus, Director of ATRC, for helping me in sending the broadcast email.

IV.2.3 Guidelines, de facto standards, and standards

As mentioned in the literature review (chapter II; also, see appendix A), there are several guidelines that have been published by different groups of researchers who have been contributing to a body of knowledge in their attempts to create a common understanding of web accessibility and its requirements. Although there have not yet been any standards that can be considered as something that everyone refers to, WCAG 1.0 is generally considered as a de facto standard as it is the outcome of WAI which is a part of W3C. WCAG 2.0 is still a working draft with the last update date marked as December 11, 2007.

At the beginning of the research, WCAG 1.0 was used extensively. However, during the consultations with the web designers, it soon turned out that WCAG 1.0 has become outdated to such an extent that most designers using this guideline are slowly starting to change their focus to WCAG 2.0. Even though version 2.0 is still a working draft, these designers are making use of its more current content as it is more applicable at current time than version 1.0. I shall discuss these further in the next chapter where the results will be discussed.

The guidelines that have been consulted in this research are WCAG 1.0, and the working draft of WCAG 2.0. Version 1.0 has been used for only the early portion of the study (which involved getting to understand the guidelines better), while version 2.0 has been applied for almost all parts of this research.

IV.3 Data analysis and model construction

The knowledge gathered in the first phase of this research has been used to analyze the specific areas in using web accessibility guidelines where difficulties are faced by the designers. These collected data have been extensively analyzed to find any traits of current accessibility guidelines that make it difficult for web designers to use them appropriately. For example, a common complaint may be about the guidelines' inability to be applied in specific situations. This can lead the representation of the goal graphs to allow analysis of the situation using goal oriented modeling for a more holistic approach.

Representations of too many requirements can lead NFR graphs to become too big to be easily handled by a user. For this reason, the concept of design patterns (Gross & Yu, 2001) has been applied to the goal graphs. This has helped in keeping focus of the goal graphs, while leaving the details to the design patterns.

There is a gulf of difference between the way that versions 1.0 and 2.0 of WCAG are designed. As pointed out in the literature review, WCAG 2.0 seemed to be a more balanced set of guidelines that approaches the accessibility issues based on principles. This has been helpful for applying them and reorganizing them using goal graphs. Moreover, the approach that has been taken by WCAG 2.0 in relating the technical aspects of the guidelines to the principles has proved to be quite well matched for use in making the design patterns and linking them to the goal graphs.

For model construction, Microsoft Visio has been used. The goal graphs belong to a special notation technique for which a Visio stencil is available. This stencil has been used for creating the goal graphs throughout the research.

Chapter V: Results of the study of web designers

V.1 Introduction

In this section, I shall only focus on the consultations with web designers and the outcome of these consultations. The outcomes are only used as a suggestive means for the research as it only considers the general observations made by the designers in understanding how the latter of the study should create the goal graphs and design patterns.

The knowledge gathered from expert ideas have been discussed in the literature review in chapter II.

The knowledge from this study is going to be used in conjunction with the knowledge of the accessibility guidelines for proposing the reorganization. Thus, the knowledge from the accessibility guidelines has been analyzed and applied in chapter VI.

V.2 Job descriptions of participants

For this study, six participants have been used. Their participation has not been used for any sort of empirical significance for this study, but rather in a suggestive way for helping in reorganizing the goal graphs.

All six participants of the consultations are web designers, but their job descriptions are a bit different from each other. They are described in the following.

- Participant 1: This participant is a web designer with an accessibility focused research unit. S/he uses the accessibility guidelines for not only designing accessible web contents, but for also performing accessibility evaluations of many government and non-government organizations. Interestingly, this participant has worked closely with the working group of WCAG 2.0. It is not clear whether s/he is a member of the working group.

- Participant 2: This participant also works for the same organization as participant 1, but is involved with more programmatic use of the accessibility guidelines. S/he creates designs using the guidelines, perform usability tests of the early designs, and also writes scripts for a project within the organization that deals with accessibility evaluations.

- Participant 3: This participant is an administrator of a cricket (sport) web site, and was involved with the recent redesign of the site. S/he has added several features in the site that helped the site solve its long standing accessibility issues.

- Participant 4: This participant is also an administrator of the same cricket (sport) site as participant 3, but is rather involved in the current maintenance of the web site.

- Participant 5: This participant works as a web programmer in a software company.

- Participant 6: This participant is a web designer who does contractual web developments.

With the knowledge about each participant's job requirement, the following classification of the number of participants per job task can be compiled.

Job title	Number of participants
Designs web sites	6
Maintains web sites as a webmaster	1
Acts as an accessibility evaluator (consultancy)	2
Programmer for accessibility evaluation tool	1
Administers usability testing with disabled users	1
Creates accessible sites due to job requirement	2
Creates accessible sites without job requirement	3
Are able to create accessible contents	6

Table V.1: Number of participants in each category of job task

From the table V.1, it is important to notice that out of the 6 participants; only 3 create accessible web sites even when they are not required to do so at their job, whereas all 6 have mentioned that they are able to create accessible web contents.

V.3 Classification of mechanisms used in designing accessible web contents

In all the meetings with the participants, the participants have guided the discussion in their own way by discussing their experiences in using the accessibility guidelines. However, there are three specific questions that each designer has been asked at one point or another. The questions are

1. Do you use any authoring tool during your web design process that helps you achieve accessibility?
2. Do you perform accessibility evaluations on the designed pages to check whether it meets the accessibility requirements?
3. How do you make sure that your designs conform to accessibility requirements?

The answers to the questions revealed quite a few important details as listed in the following tables. It can be noticed that there are quite significant differences in the way

that the designers design accessible web contents. What is interesting to notice is that, one of the participants does not use any authoring tool in creating their web designs.

Type of tool usage		Number of participants
Designs sites with authoring tools (such as DreamWeaver and FrontPage)		5
Designs sites without authoring tools		1
Relies solely on authoring tools to guide them through designing accessible contents		2
Relies on authoring tools along with background knowledge in designing accessible contents		3
Designs web sites without any authoring tools		1
Evaluates designs with accessibility evaluation tools	Always	3
	Sometimes	2
	Never	1

Table V.2: A table showing the breakdown of authoring tool usage among the participants

The following table indicates the amount of accessibility evaluations performed by the participants after designing each web page.

When	Number of participants
Always	2
Sometimes	1
Never	3
Only when required	2

Table V.3: A table indicating the number of participants who evaluate each design for accessibility conformance using automated tools

The final question about how the designers ensure their conformance to accessibility requirements generated a few interesting responses. Referring back to table V.1 where all 6 participants have mentioned that they are able to create accessible web contents, one would assume that all of them have at least consulted the guidelines at one point or another to see how they can create accessible web contents. Table V.4 has the results of the question.

Mechanism to ensure conformance		Number of participants
Through detailed understanding of guidelines		2
Through some understanding of the guidelines		1
By solely depending on authoring tools		2
By partially depending on authoring tool and some understanding of the guidelines		2
By referring to guideline during design	Always	0
	Sometimes	2
	Never	4
By analyzing other accessible solutions and checking how they have performed their evaluations		1
By using a home-grown list of techniques that they always follow		1
Never consulted any of the accessibility guidelines		2

Table V.4: A table indicating the mechanisms that designers take in ensuring their conformance to accessibility guidelines

It is evident by now that even though many may have said that they are able to design accessible web pages, only two admitted to have used the guidelines thoroughly. Surprisingly, none of the designers refer to the guidelines during each design, and only two of them refer to the guidelines sometimes when designing accessible web pages. One of these two participants, who refer to the guidelines sometimes, did mention that s/he does it for making references to the guideline s/he is using for a specific component within the design.

V.4 Observations of participants in general

All six participants of the consultations have quite different types of experiences based on their job. Three participants have a very deep understanding of accessibility guidelines as they have to apply these guidelines in their work regularly. I shall outline the observations in the following.

V.4.1 WCAG 1.0 is outdated

The very first consultation was an eye opener as it was with one of the more experienced individuals who have deep understanding of the accessibility guidelines. The argument that s/he made about the inability of WCAG 1.0 for not being able to provide much help to the designers is that it is too old and outdated. It was designed at a time when the web was in its early years. Thus, WCAG 1.0 lacks the ability to provide guidelines that are current with the advancement in web technologies.

V.4.2 Accessibility guidelines are bulky

Generally, it seemed that almost all participants agreed with the fact that the accessibility guidelines are bulky. This claim is also supported by many researchers. It has been discussed at a great length in literature review in chapter II and has also been an issue that has been critiqued in chapter III.

V.4.3 No specific method for applying guidelines in design

The participants have shown quite a few visibly different approaches they take for using the accessibility guidelines. The approaches are:

- referencing the guideline or checkpoint number from within the HTML code of a web design.
- using past experience and knowledge on using a specific guideline (possibly the most commonly used guidelines such as the requirement of alternative texts)
- analyzing other similar designs in popular web sites that comply to web accessibility guidelines
- writing notes in personal notebooks on the areas in a design that a guideline might be useful, and then visiting this area later and applying any relevant guidelines
- using a personal checklist (not the standard one provided for WCAG 1.0) of accessibility issues that they feel are necessary to solve, and using that checklist for evaluating a design

V.4.4 Same guideline is applied in all cases regardless of situation

It has been observed from the consultations that the designers always use the same guideline for all cases, regardless of the situation. There are specific situations where a guideline may not be sufficient in solving an accessibility issue due to other competing issues that might reduce usability for a targeted user.

V.4.5 Guidelines applied cannot be traced back

Once that the guidelines are applied in designing the web contents, it seems that there may not be a way using which their usage can be traced back. Only one designer has indicated the use of a referencing mechanism from within the HTML code. This may be considered as a traceable solution, but it is also of great importance that why a specific guideline has been used is also traced back. Furthermore, it is important that the reasons for not applying a guideline where it should have been applied be traced back.

V.5 Analysis

The consultations with the web designers have been of great significance for this research. Although the small sample of the consultations does not provide statistical validity, the knowledge about everyday situations in using the accessibility guidelines is what made it such an important part of this research.

It seems that there is a possibility that application of accessibility guidelines by themselves is not sufficient. The guidelines are applied by the designers in their own ways, which can possibly leave accessibility issues unnoticed. A systematic method for applying the guidelines is necessary. Particularly, the approach should also help solve some of the existing issues in related to traceability of the usage of guideline, allow usage of the guideline for specific situations, and also allow usage of the guideline for performing evaluations.

It has been sensed that using WCAG 1.0 for this research is going to be a step backward. Since WCAG 2.0 is more focused in a principle oriented way, it is going to be easier to remodel this guideline for use with goal graphs. Furthermore, as noted in the literature review, the use of design patterns becomes easy if WCAG 2.0 is being used, since the techniques are organized in a way that allows pattern identification quite effectively.

It is rarely possible to create a set of guidelines that will fit the one-size-fits-all notion. For example, I have noted in the literature review that the concept of design patterns is that it is a documented method of retaining knowledge for future use. But what is important to notice here is how the patterns are considered. Patterns are typically used for retaining knowledge on specific issues, and they have their own focus in solving the issues. A guideline is not a pattern, and it should not be. A section of a pattern or a specific issue presented in a guideline should rather be a pattern. And that is why,

remodeling the guidelines in a way so that they can be applied in a systematic manner is important.

V.6 Implications of the study

This study has provided support for the background research, and has provided a few eye-opening details that must be kept in mind for this research. Furthermore, it has provided a better understanding of why WCAG 1.0 is not a good choice for this research. Even though the study has not been used for empirical analysis, it has provided this research a much needed view of the possible work practices of web designers.

Chapter VI: Reorganizing the guidelines using goal graphs and design patterns

VI.1 Deconstructing the guidelines

The process of reorganization of the accessibility guidelines started with deconstruction of the goal graphs. In this process, my main intention is to identify the specific bits from the guidelines that will enable me to reorganize these guidelines using goal graphs.

As discussed in section III.2, the softgoals are qualities that can be represented by forming the NFR graph. Here, it is those softgoals (the cloud shaped items) in the NFR graphs that need to be identified from the accessibility guidelines. Let us consider guideline 1.1 of principle 1 of WCAG 2.0 as an example and deconstruct it for the purpose of representing it using the goal graphs.

Principle 1: Perceivable - Information and user interface components must be perceivable by users

Guideline 1.1 Provide text alternatives for any non-text content so that it can be changed into other forms people need such as large print, braille, speech, symbols or simpler language
Understanding Guideline 1.1

1.1.1 Non-text Content: All non-text content has a text alternative that presents equivalent information, except for the situations listed below. (Level A) How to meet 1.1.1

- **Controls-Input:** If non-text content is a control or accepts user input, then it has a name that describes its purpose. (See also Guideline 4.1.)
- **Media, Test, Sensory:** If non-text content is multimedia , live audio-only or live video-only content, a test or exercise that must be presented in non-text format , or primarily intended to create a specific sensory experience , then text alternatives at least identify the non-text content with a descriptive text label. (For multimedia, see also Guideline 1.2.)
- **CAPTCHA:** If the purpose of non-text content is to confirm that content is being accessed by a person rather than a computer, then text alternatives that identify and describe the purpose of the non-text content are provided and alternative forms in different modalities are provided to accommodate different disabilities.
- **Decoration, Formatting, Invisible:** If non-text content is pure decoration, or used only for visual formatting, or if it is not presented to users, then it is implemented such that it can be ignored by assistive technology.

Figure VI.1: Guideline 2 of WCAG 1.0 (underlined text are hyperlinked)

It can be noticed that the principle that it is trying to help achieve is “perceivability”, which is to define the nature of the web components to be perceivable to the users. The main objective of the guideline 1.1 is to tell the designer to provide textual alternatives for non-textual components of the web site, so that the principle of “perceivable information” can be achieved. Following this, the guideline takes a narrower focus in 1.1.1, where it discusses non-textual components to be specific. And further down, it narrows down the focus even further by narrowing it by specific types or uses of these non-textual components (such as control-inputs, media, and decoration items).

Let us interpret the above according to the goal representation technique. To start off with, the primary principle can be considered as the top level goal. In this case, perceivable information may be a top level goal that a designer wants to achieve. Following is the goal graph that represents perceivability of information and user

interface components. For simplicity, we can consider these generally as the user interface (UI).

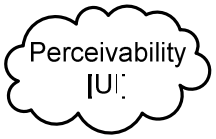


Figure VI.2: Goal graph for the top-level goal

This guideline gets more specific at section 1.1.1, where the designers are instructed to provide textual alternatives for all non-text contents. We can represent this using the following notation.

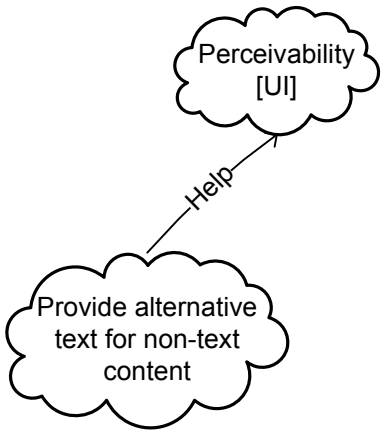


Figure VI.3: Goal graph indicating a HELP link for contribution

The reason that the clouds are being connected using a HELP link is because simply by providing an alternative text for non-text content does not achieve perceivability of user interface (UI). Rather, this helps in achieving the perceivability of UI. Had this been the only way of achieving perceivability of the UI, the goals would have been joined using a MAKE link.

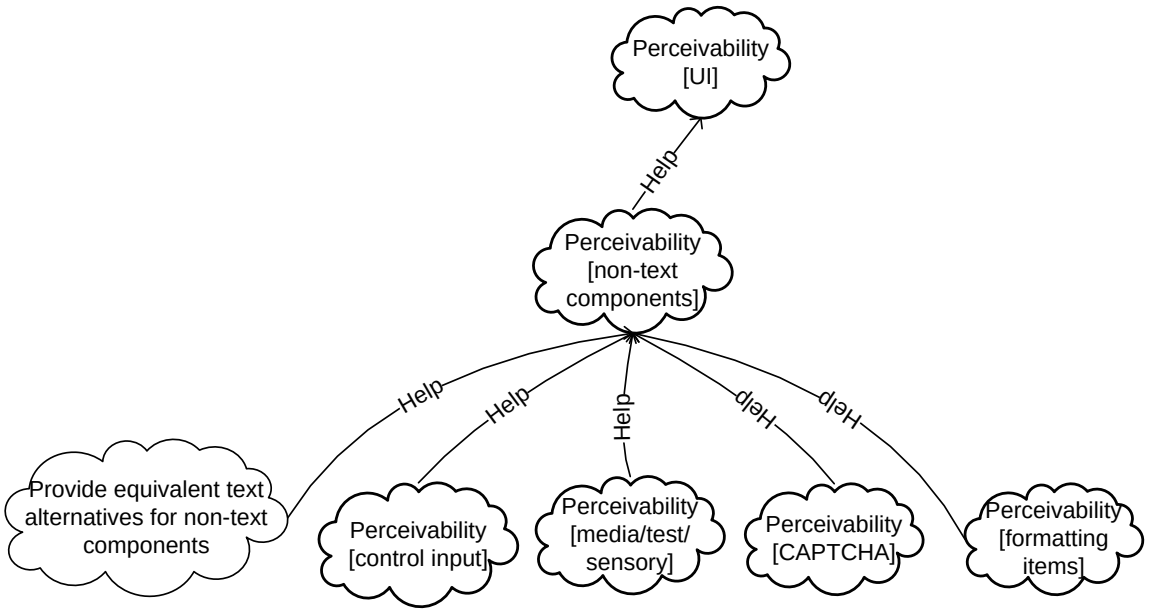


Figure VI.4: Goal graph depicting several alternatives, with only one of them operationalized

Once again, the help links appear here, since each individual ways of making information perceivable will contribute in achievement of the top-level goal to some extent. Furthermore, even though there are exceptions that are mentioned in the guideline, there are also alternative ways that are provided for achieving perceivability for those exceptions. However, other than the exceptions that exist, perceivability of information is a goal that can be achieved by providing equivalent text alternatives for non-text components. This is called operationalization, and is represented in the above graph using a thick-lined cloud.

Note that this specific guideline can be interpreted in a different manner, by indicating that there are conditions that are involved, which are not represented in the goal graph developed above. Conditions such as “[a]ll non-text content has a text alternative that presents equivalent information, except for the situations listed below” are missing altogether from the above model. While this may be a crucial bit of detail, it is nevertheless important to understand that these exceptions also have their own means of achieving perceivability. That, on the other hand, allows us to see how the goal graph takes care of it by simply depicting it as an alternative to achieving the solution, and

weighs the achievement of the top-level goal based on the achievement of these alternative solutions. This reiterates us to the issue of why the HELP contribution link is used here, rather than stronger contribution links such as MAKE, as a MAKE contribution link indicates an operationalized goal as a sufficiently strong way of satisficing its parent goal.

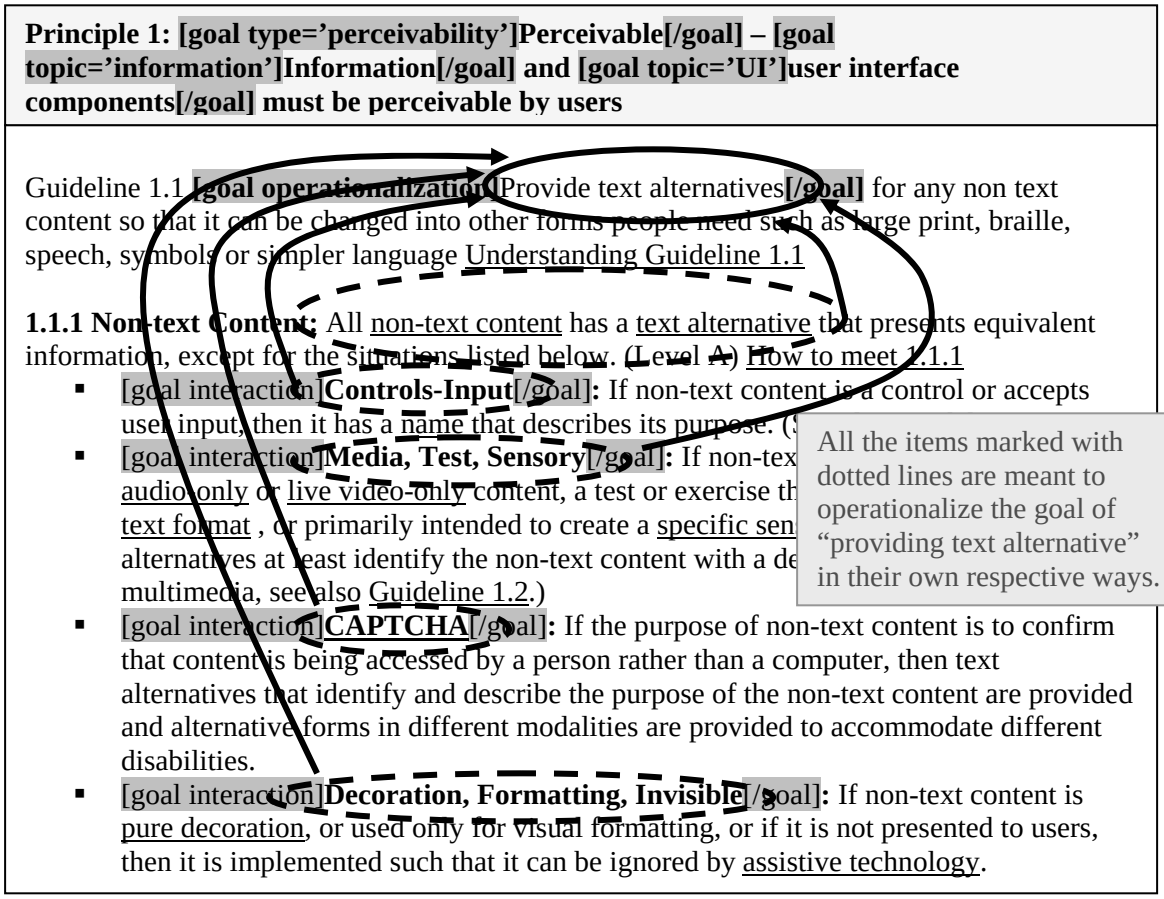


Figure VI.5: The tagged version of guideline 1.1 of WCAG 2.0

To operationalize the alternatives (perceivability of the exceptions), we can rely on the guideline (as described below), and extract the useful details using the proposed means of tagging the content as shown in the diagram VI.5.

VI.2 Creating goal graphs

Utilizing the tagging technique discussed in section VI.1, we can start plotting the goal graphs. The following goal graph can be plotted using the tagged items and the way they are presented to help the overall goal. As we can see, the following graph does not have any item that has been operationalized. Thus, the goals need to be decomposed even further for it to be operationalized.

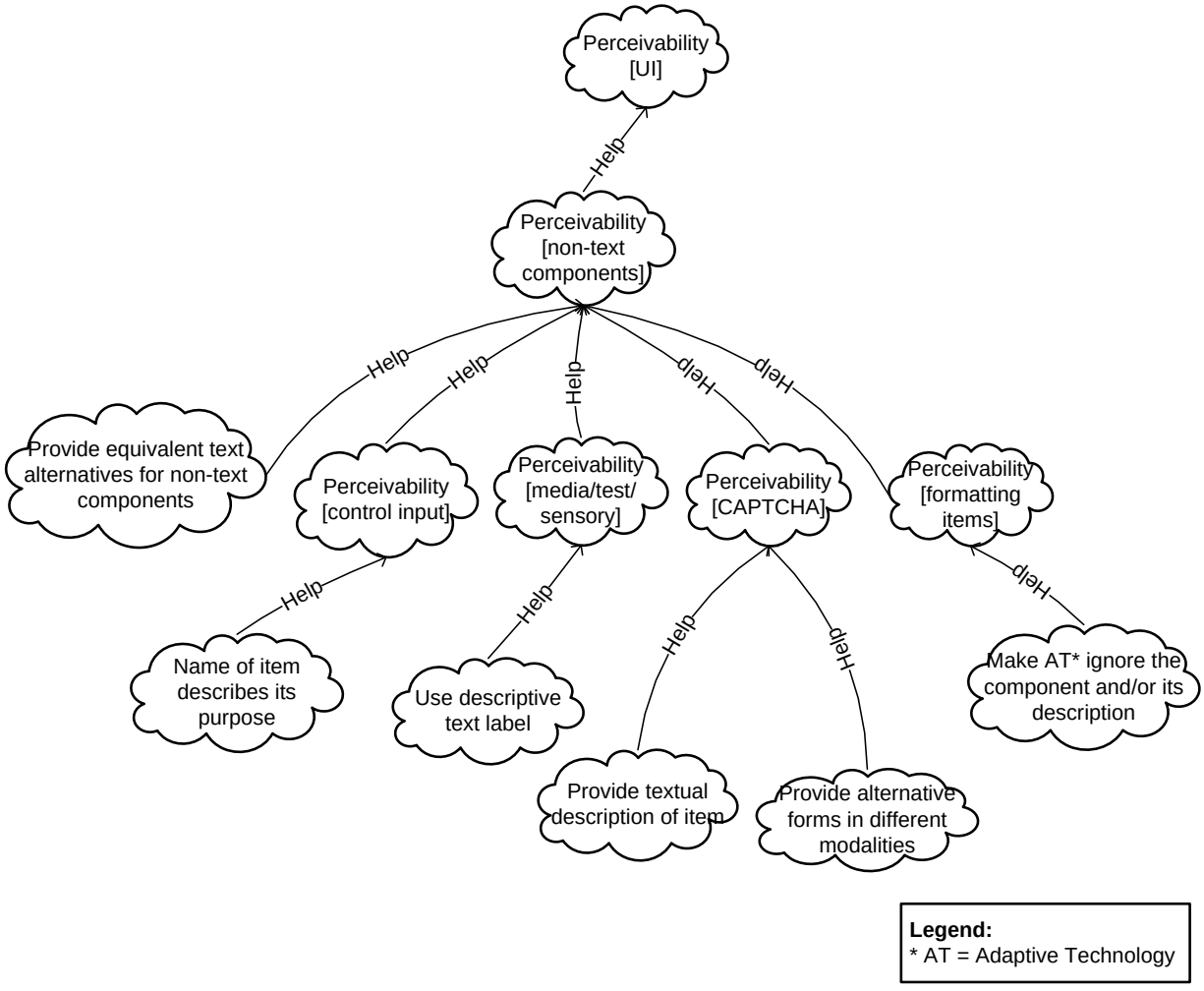


Figure VI.6: Goal graph depicting more operationalized goals, but still with some without being operationalized

In guideline 1.1.1, a hyperlink that reads "How to meet 1.1.1"[15] takes the user to a new page, where there are details and situations provided for the designer to analyze. The situations provided there are explained further, and multiple alternative solutions are provided there based on the situation and technology being used. Consider the first two situations described there.

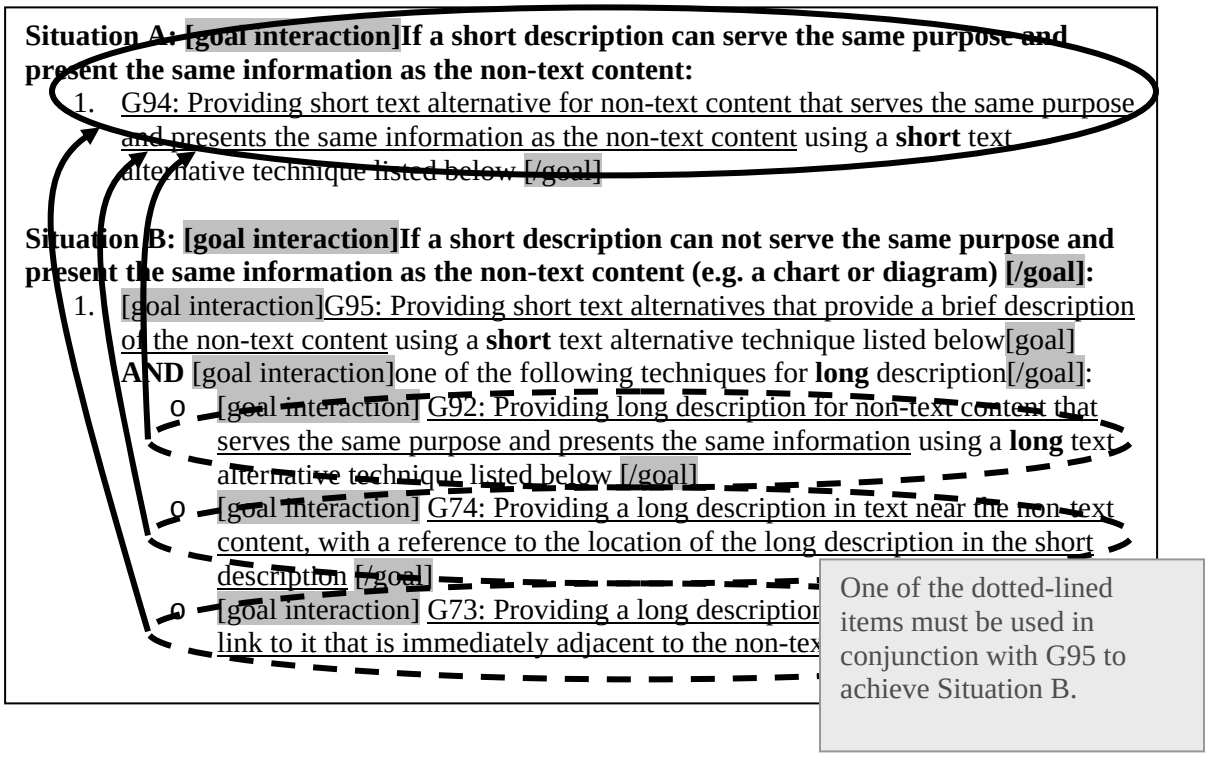


Figure VI.7: Two situations described in guideline 1.1.1 of WCAG 2.0

It is evident from the description of situation A that it is the simplest of all situations, where the description of a non-textual component can be provided very briefly. However, that may not be the case. For example, charts are non-textual components of web pages, and they cannot be described very briefly. Thus, situation B outlines the ways that a

[15] You can access this by visiting
http://www.w3.org/WAI/WCAG20/quickref/20070517/Overview.php#text-equiv-all

combination of short and long descriptions can be used when only a short description is likely not going to suffice. Notice the use of AND, and the alternatives provided for the long description. This can be represented using NFR graph in the following way, with the appropriate use of AND and OR contribution links.

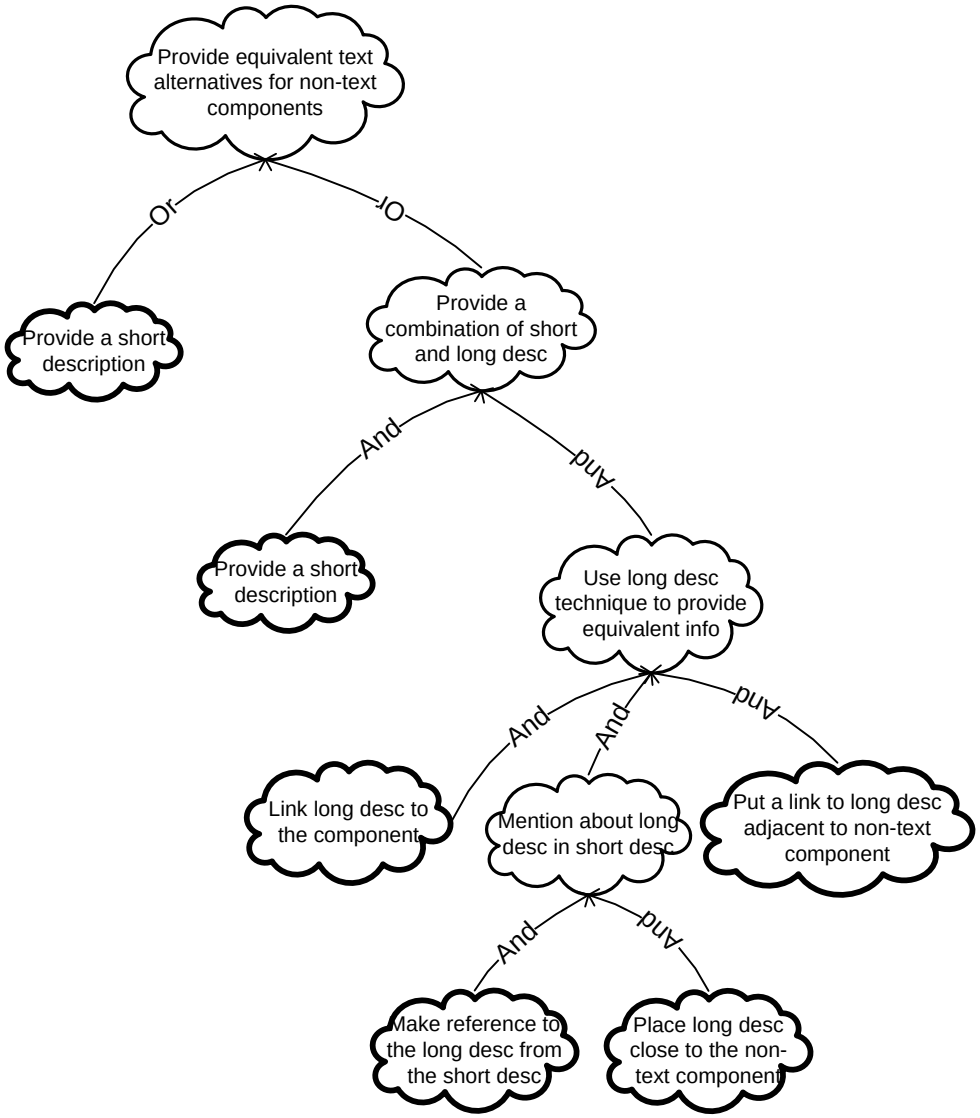


Figure VI.8: A goal graph representing the Situation A and B of guideline 1.1.1

The top node of this graph is to show that this is a continuation of the graph in figure VI.6. It is being put here separately for simplicity.

A similar mechanism can be continued by following the descriptions and solutions for situations C through F. The goal graphs can be created using the AND, OR, or HELP contribution links based on the extracted dependencies and alternatives. Let us transform situation C into its equivalent goal graph.

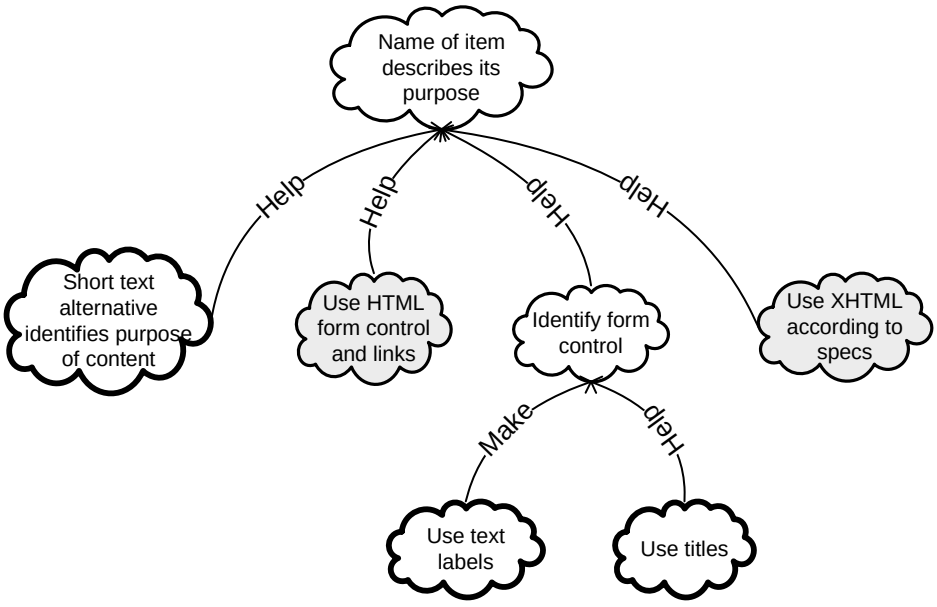


Figure VI.9: A goal graph representing the Situation C of guideline 1.1.1

In this graph, the shaded clouds represent the techniques that are not yet defined in WCAG 2.0[16] but have been mentioned in the guidelines nevertheless. I shall only highlight these clouds, and not consider them any further in the research. In figure VI.9, notice how the softgoal "identify form control" is being used, where "use text label" is an operationalized goal that has a MAKE contribution to this goal, whereas the

[16] This can be considered as one more reason why WCAG 2.0 has not yet reached a final published version yet. In many parts of WCAG 2.0's current working draft, references have been made to the yet-to-be-defined techniques with a "future link" flag.

operationalized softgoal “use titles” only make a HELP contribution to this goal. It appears this way due to the description in situation C described in the guideline 1.1, as it suggests a designer to use text labels primarily, while it suggests using titles only when text labels cannot be used.

Interestingly however, there is an operationalized goal in figure VI.9 which suggests that designers should use short text alternatives that identify the purpose of the content (or component to be specific). Checking back in figure VI.8, it can be noticed that a similar operationalized goal (provide a short description) exists for another softgoal. In the goal oriented modeling technique, this can be taken care of by making a HELP contribution link from the operationalized goal that reads “Provide a short description” to the top goal in figure VI.9. This technique shows how different sections within the guideline are complementary to each other. This is demonstrated in figure VI.10.

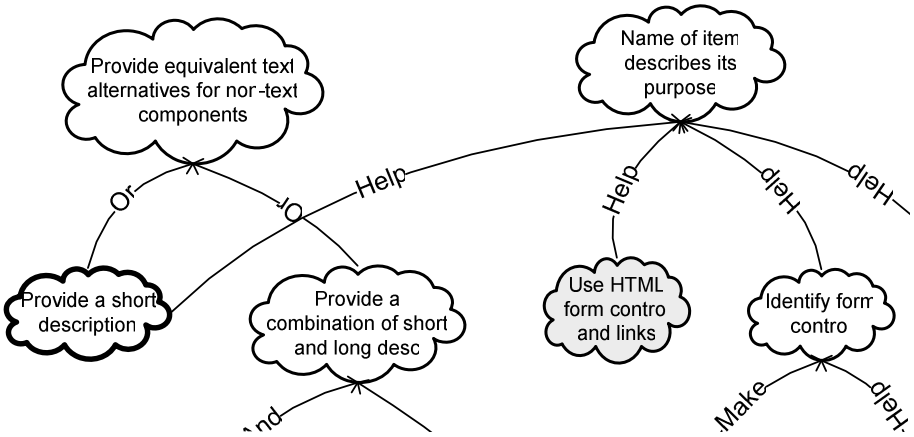


Figure VI.10: Demonstration of how situations A, B, and C of guideline 1.1 of WCAG 2.0 can be brought together.

A similar situation arises with the goals titled “provide a short description” in figure VI.8. Notice how this goal appears twice, for very similar purposes. In one case, it directly operationalizes the top goal. In the other case, it helps operationalize the refinement of the top goal. It seems possible that the techniques for providing short descriptions are the same although the purpose for doing this may be different. The purposes have been

explicitly demonstrated in the goal refinement by indicating that for each one of them, the only goal that they are trying to operationalize is the goal that they are an immediate refinement of (although they help achieve the top goal as both belong to the graph of the top goal at some refinement level). We used the HELP contribution link above for making this connection. However, this connection requires an AND contribution link, as demonstrated below.

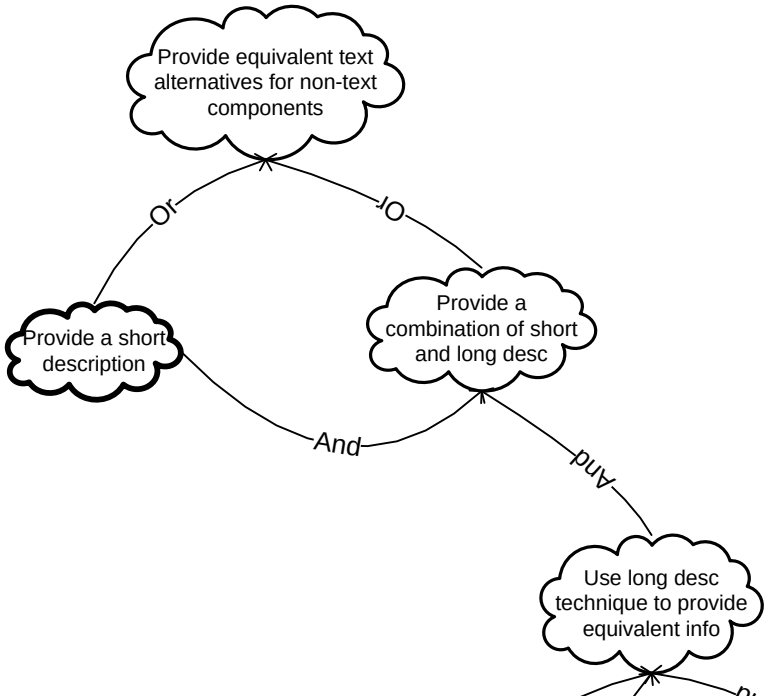


Figure VI.11: Providing an AND contribution link to remove duplicate goals

This technique can be followed in a detailed manner and a whole goal graph can be formed for guideline 1.1 based on the situations A through F. This is shown in figure VI.12. Note that there are adjustments that have been made in the goal graph to accommodate merging of related goals and/or making contribution links to related softgoals. In figure VI.12, particularly note the way that the graph takes shape, and the reasoning that is possible to be obtained from reading the graphs. For example, notice the use of AND and OR links, along with the HELP, and MAKE links.

Suppose that a designer is trying to see what s/he needs to do in order to make a control input perceivable. So, the designer will first start by looking at the “perceivability” of

user interface (UI) node of the graph. It shows that to meet this goal, the designer has to achieve perceivability of the non-textual components. Notice that a control input is a non-text component, and so the designer needs to read further into the graph. Now, once the designer notices that control input is an item that is specifically discussed in the following node that seems to help achieve the top goal, s/he will continue to that node. Note that the other nodes at this same level that have a HELP contribution link that apply to the perceivability of non-text component are irrelevant to the designer, since those are there to help the designer improve perceivability of the non-text components other than control inputs. However, when perceivability of control inputs is in question, the nodes that have a HELP contribution link to this node are all meant to help achieve its perceivability.

Note that all these nodes do apply to the perceivability of control inputs, which is why the designer has no option but to consider all of them in his/her design. However, technically it does not necessarily mean that performing the guidelines in all the four nodes will necessarily make a control input fully perceivable. It rather means that doing these will satisfice the goal of perceivability of control inputs.

Further down into the graph, a goal is present that requires the designer to identify form controls. Notice how the two operationalizing goals are linked to satisfice this goal. The MAKE contribution is a stronger contribution than HELP, and if the designer is capable of using text labels in the technology s/he is using, that will ensure that s/he has properly identified the form control. However, if the designer chooses to only use the titles of the form control, s/he will certainly satisfice the goal of identifying form controls, but not as strongly as s/he would have if s/he used a text label. This is a very effective way of indicating an alternative method for doing something, which not only provides the alternatives, but also qualitatively provides the impact that each alternative will have in the overall design of the web contents.

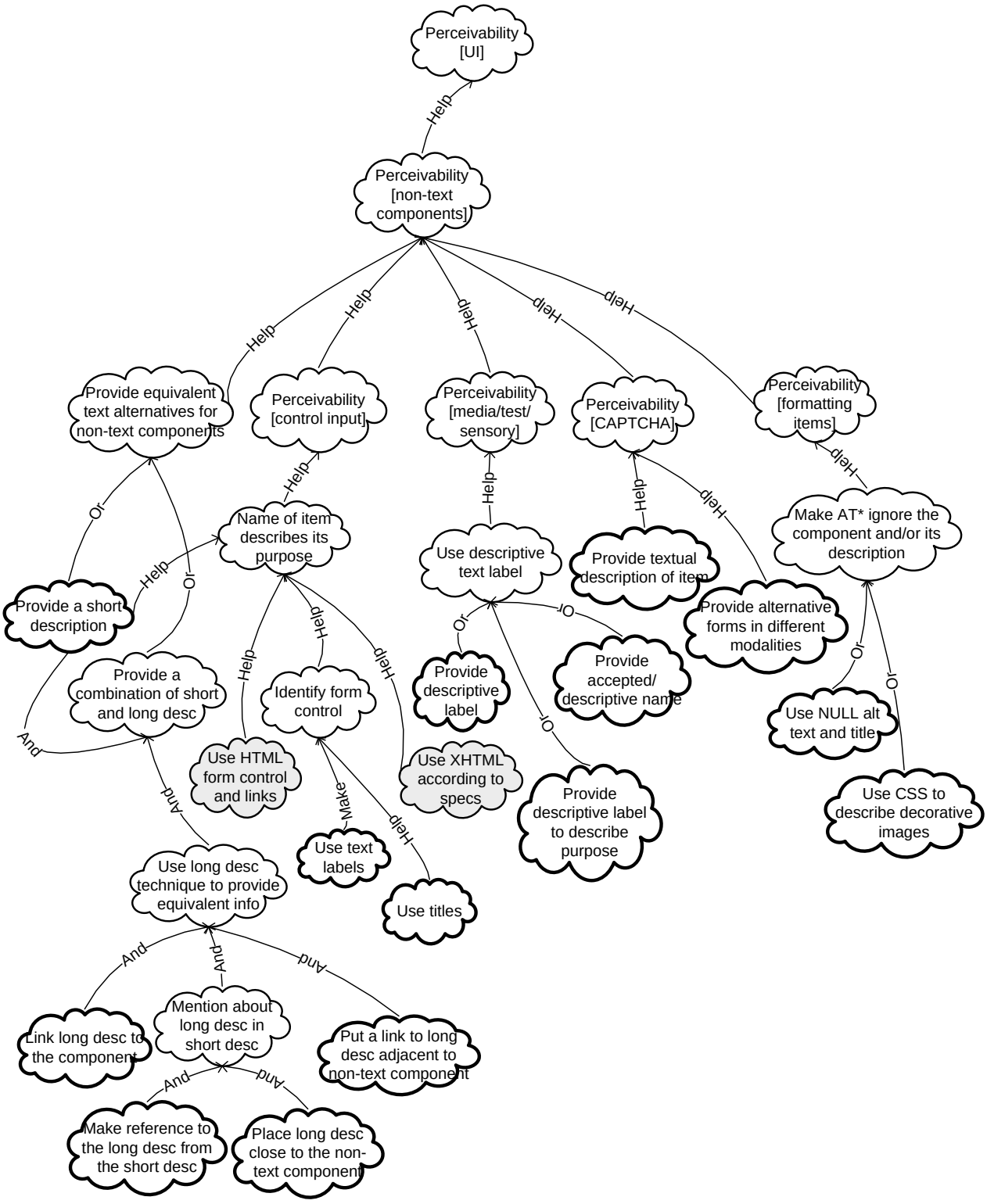


Figure VI.12: The goal graph showing guideline 1.1 of WCAG 2.0

One thing that is noticeable in the goal graphs so far is that, the operationalizations these graphs do not provide a technical guidance. The convention of the goal oriented modeling technique is to convey such message in the graph. However, in my proposed approach, the operationalizations are going to be considered without any technical content to it. The reason is the same as why WCAG 2.0 took a principle based approach rather than technical.

Since web technologies are changing, newer technologies are coming into use. And in the essence of accommodating the broad range of web technologies, the technical specifications are only kept for achieving the principles. Since different technical specifications are required for different web technologies, the final technical specifications of the reorganized guidelines are kept separate from the goal graphs. That way, designers of web sites will be able to use the guidelines in a general fashion, and apply the techniques for their chosen technologies to comply with the guidelines.

In the following section, I shall elaborate the technique that can be used for providing the technical guidance to the designers in conjunction with the goal graphs.

VI.3 Forming design patterns

It is hardly possible that technical solutions and explanations are represented in the goal graphs that we have looked at so far. Since goal graphs contain clouds with text in them, the amount of characters within the clouds is limited. In fact, putting too much text might overwhelm the user of the graphs. In contrary however, it defeats all the purpose of providing a guideline if the user of the guideline is not given the ability to see what s/he needs to do to achieve accessibility.

Since WCAG 2.0 is principle focused, rather than technique focused like its predecessor (WCAG 1.0), there is a limitation that the guideline has in providing the actual technique

to the user. Once a user is looking at a certain guideline, such as guideline 1.1 (discussed in sections VI.1 and VI.2), they have to click two to three times before they can get to the technical details.

It is evident from the guidelines that most of the technical details only cover HTML and Cascading Style Sheets (CSS). They do not go over technical details of other web technologies such as Flash. Certainly, it is not possible to go over all the technical details of all available web technologies, and W3C should receive all the credits for making WCAG 2.0 more principle oriented so that the technology specific technical details can be worked out by interested individuals.

As I mentioned in section II.3, design patterns are reusable knowledge, and they can be formed into a network of related patterns to form a solution to an existing problem. This is exactly where this concept can be applied in the situation at hand. Since design patterns are reusable knowledge, it can be used to represent the technical details of the guidelines quite easily. The reason is, each guideline in WCAG 2.0 has a “How to” link next to it, which links the guideline to a set of techniques that can be followed to reach a solution that solves the particular accessibility concern in hand. For example, guideline 1.1.1 has a link that takes the user to a section where the following details are provided:

- Sufficient techniques for 1.1.1
- Common failures of 1.1.1
- Advisory techniques of 1.1.1

It is quite uniform among each guideline, and thus provides us with three useful technical contents for forming patterns. Here is an example of how the design pattern may look.

Context: A user is trying to access a web site with both textual and non-textual contents

Problem: Non-text components of web sites cannot be perceived by adaptive technologies (AT).

Forces:

- Different web technologies require different mechanisms to make them perceivable to an AT.

Solution:

Sufficient techniques	...
Common failures	…
Advisory techniques	…

Figure VI.13: A sample general pattern

The above sample design pattern can be written using a template since WCAG 2.0 uniformly uses “sufficient techniques”, “common failures”, and “advisory techniques”. They are defined in the following.

- **Sufficient techniques**: These are the techniques that can be used to conform to the corresponding guideline. By “sufficient”, it could mean that the designer only needs to know the stated techniques to conform to the guideline. Thus, a probable use of this way of mentioning the required techniques is to enable the creation of a comprehensive list of techniques that one can possibly use for creating a manual for a specific web site.
- **Common failures**: These are the common problems that one can face due to either misconceptions about using a certain guideline, or due to certain details about a guideline that the designer may not have known about. It can be used for troubleshooting purposes by providing a comprehensive list of possible issues that may lead to the inability of a web design to meet accessibility requirements even though the designer has used the guidelines.
- **Advisory techniques**: These are the techniques could potentially help a designer make their design more accessible, although they are not required for compliance with WCAG 2.0. The working group (WCAG WG, 2007) also mentions that even contents that are WCAG 2.0 conformant may not be fully accessible to every

person with a disability, which could rise due to people with language, learning, and cognitive disabilities, and multiple severe disabilities.

The next step is to find the related patterns for the rest of the guideline, which the pattern in figure VI.13 will guide the designer to read for specialized details. The term “specialized” is used here rather synonymously to Unified Modeling Process (UML) (Craig, 1998) to indicate that the related pattern for figure VI.13 to be a more specialized way of looking at a particular problem, while the pattern in figure VI.13 is in a more generalized form.

To maintain consistency, we could adopt the sample pattern in figure VI.13 to create the more specialized patterns. However, only the heading items (context, problems, forces, and solution) are going to be maintained in other patterns. Whatever goes within the different headers depend on the patterns themselves, and what they are trying to solve. The specialized patterns will aim at providing a single solution to a particular problem by focusing on only one particular issue of the problem. Let us assume that the pattern is for providing the solution for making a control input item accessible. In that case, we can have the following pattern as a solution to the problem.

Context: The objective of this technique is to use the `title` attribute to label form controls when the visual design cannot accommodate the label (for example, if there is no text on the screen that can be identified as a label) or where it might be confusing to display a label. User agents, including assistive technology, can speak the `title` attribute.

Problem: Making accessible the HTML, XHTML form controls that are not identified using `value`, `alt`, or element content.

Forces:

- User agents will display a tool tip when the mouse hovers above an `input` element containing a `title` attribute.
- If no `label` is available, JAWS, Window-Eyes, and Home Page Reader speak the `title` attribute when the form control receives focus

    - ✓ JAWS 6.0 and later can be set to speak both `label` and `title` when the two items are different; however, very few users are aware of this setting.
    - ✓ WindowEyes 5.5 has a hot key, ins-E, that will display additional information, including the title attribute, for the item with focus.
    - ✓ Home Page Reader 3.04 will speak the title attribute of any element with focus when the control-shift-F1 keys are pressed simultaneously.

Solution:

Example	▪ Example 1 ▪ Example 2 ▪ Example 3
Resources	▪ Resource 1 ▪ Resource 2
Related techniques	▪ Technique reference number 1 ▪ Technique reference number 2
Tests	▪ Procedure ▪ Expected results

Figure VI.14: A sample specialized pattern

As it can be seen, the details under the “solution” heading have now taken a different shape. In the previous diagram, it contained sufficient techniques, common failures, and advisory techniques. But now, it contains a specialized way of solving an issue, some relevant resources and techniques, and test procedures and expected results for this solution.

The techniques that WCAG 2.0 guidelines have are a good fit for being used as design patterns in the proposed reorganization. The best part is, to use these techniques as design patterns, one does not have to transform these technical sections, thus reducing complexity of the process.

This instance of related patterns is likely to take the shape of a star, where the generalized pattern is at the center, and the specialized patterns are all around it to provide the solution. Since patterns are reusable knowledge, they can be applied in solving other accessibility issues as well. Thus, a specialized pattern in a relationship with the general pattern may also be connected to another general pattern. Following is how this is likely to look in conceptual terms.

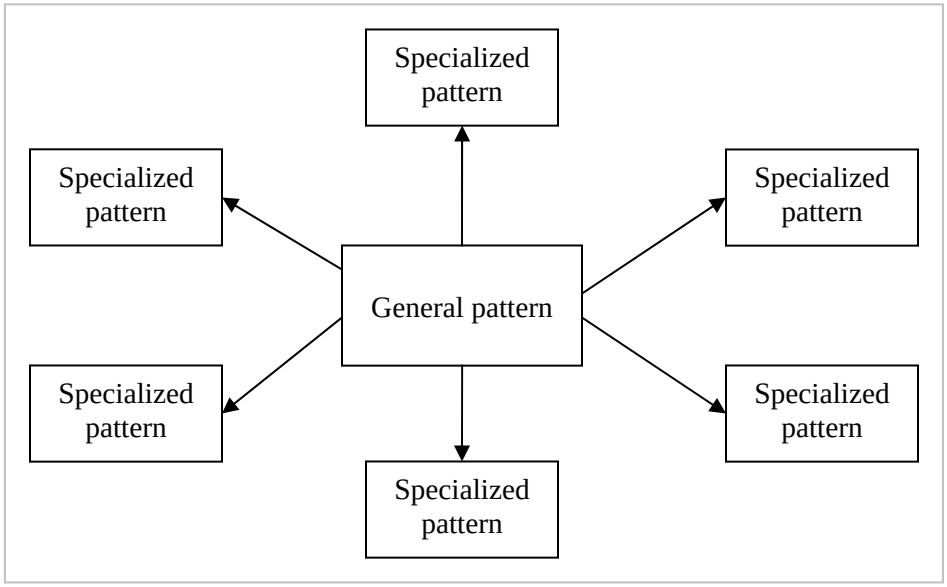


Figure VI.15: Conceptual view of a pattern relationship in the proposed approach

In the next section, I shall take a closer look at the arrangement and linking of the goal graphs, the general patterns, and the specialized patterns.

VI.4 Linking goal graphs and design patterns

I have demonstrated the recommended technique to reorganize the guidelines using goal graphs, and how the technical details can be reused to form design patterns. I shall now demonstrate the way that both these (the goal graphs, and the design patterns) can be used together as a general reorganization of the accessibility guidelines.

Since the goal graphs and design patterns are meant to guide designers, sufficient guidance should be given to the designers to be able to make the connection between a goal graph and the specific design pattern that relates to the operationalization of the goal. There should be means of referring to specific design patterns, so that designers can follow those references and get to the design pattern that s/he is required to consult. A means of navigating from the goal graphs to the design patterns needs to be established. Not only that, it is also necessary to establish a means for navigating from the generalized design pattern to the specialized design patterns as well. Thus, this is a two-step process, and I shall discuss them in the following sections.

VI.4.1 Creating the pattern network

The conceptual view of the two types of design patterns (generalized and specialized) that have been identified in the previous section has been shown in figure VI.15. By taking advantage of the consistency of the contents of these patterns (context, problem, forces, and solution), a numbering system can be added uniformly to each pattern. We can call this a pattern number.

There are a few possible ways of assigning the pattern numbers to the design patterns. Possibilities are explained in the following table.

Possibility	Rule	Examples	Advantages	
1	Start at 1; increment by 1; all patterns have numerical numbers;	22, 54, etc.	▪ Patterns are all sequentially numbered;	▪ Diffic corres ▪ Diffic genera patter
2	Each pattern has a topic (navigability, perceivability, etc) followed by a number; each number has a digit followed by a decimal value;	Perceivability 1.3; Navigability 3.2;	▪ Easy to identify what principle the pattern relates to;	▪ Diffic assign to gen ▪ Diffic genera patter
3	**Generalized patterns**: use a topic (navigability, perceivability, etc) followed by a number; numbers are incremented by 1; **Specialized patterns**: use the technique number assigned in WCAG 2.0 as pattern number	Perceivability 2; Navigability 1; G90; F54;	▪ Easy to identify corresponding principle for generalized pattern; ▪ Easy to distinguish generalized patterns from specialized patterns; ▪ Can improvise on WCAG 2.0's related techniques to link to other specialized patterns;	▪ Diffic assign to gen
4	**Generalized patterns**: use guideline number as the pattern number; **Specialized patterns**: use the technique number assigned in WCAG 2.0 as pattern number	1.1.1; 1.3.2; G90; F54;	▪ Easy to identify what guideline the generalized pattern relates to; ▪ Guideline number for generalized pattern can be reused; ▪ Easy to distinguish generalized patterns from specialized patterns; ▪ Can improvise on WCAG 2.0's related techniques to link to other specialized patterns;	▪ Future guidel guidel invalic

Table VI.1: The four possible ways of assigning pattern numbers

As it can be seen from the four possibilities presented in the table above, it seems that the easiest for our reorganization of accessibility guidelines will be possibility four, while possibility three is also a good candidate. The advantage of possibility four is that, we can improvise on the guideline numbers from WCAG 2.0, making it easier for us to associate the generalized patterns with the guideline in hand.

The third approach has the advantage of giving the patterns a goal-oriented modeling approach, by having the numbering scheme adopt the principle that the guideline refers to. That means, if it is guideline 2.1.1, it could be rewritten as Operable 1.1. Even though a designer is expected to get to the pattern by following the goal graph, thus having an

idea on what principle the pattern is trying to implement, numbering the pattern using the principle is likely to add to the usability of these guidelines.

Both approach three and four are going to make conversion easy for the specialized patterns. This is because, each of these specialized patterns are in reality the specific techniques that are listed in WCAG 2.0. They follow a unique identification scheme, where the alphanumeric codes such as G90 and F54 refer to specific types of techniques that can be identified by the first character (or the first few characters in some cases). In WCAG 2.0, the techniques have identification codes starting with the following.

- F: which refers to Common failures
- SCR: which refers to Client-side Scripting Techniques
- C: which refers to CSS Techniques
- G: which refers to General Techniques
- H: which refers to HTML Techniques
- SVR: which refers to Server-side Techniques
- SM: which refers to SMIL Techniques
- T: which refers to Plain Text Techniques
- ARIA: which refers to ARIA Techniques

That means that G90 refers to a general technique, which is at number 90 in the sequence of general techniques.

The specific techniques listed in WCAG 2.0 also have a section where related techniques are listed. This linking is done using the technique identification number. Thus, once the conversion of these techniques occurs, and the specific techniques are converted to specialized patterns, the techniques will still be able to link to the other techniques without any additional conversion procedure.

Based on my analysis of approaches three and four, it seems that they are both well-suited for the needs of this research. Since approach four reduces the complexity of spending additional time in assigning the generalized pattern numbers, I shall use that for

the rest of my research. Following are two sample patterns, one of which is a generalized pattern, and the other being a specialized pattern.

Pattern ID: 1.1.1

Context: Description of the context here…

Problem: Problem statement here…

Forces:

- List of forces here…

Solution:

Sufficient techniques	▪ G90: Providing keyboard-triggered event handlers ▪ G87: Providing closed captions ▪ …
Common failures	▪ F8: Failure of SC 1.2.1 due to captions omitting some dialogue or important sound effects ▪ …
Advisory techniques	…

Figure VI.16: A generalized pattern indicating its pattern ID

Pattern ID: G90

Context: Description of the context here…

Problem: Problem statement here…

Forces:
- List of forces here…

Solution:

Example	▪ Example 1 ▪ Example 2s
Resources	▪ Resource 1 ▪ Resource 2
Related techniques	▪ G91: Providing link text that describes the purpose of a link ▪ H77: Identifying the purpose of a link using link text combined with its enclosing list item ▪ C7: Using CSS to hide a portion of the link text ▪ …
Tests	▪ Procedure ▪ Expected results

Figure VI.17: A specialized pattern indicating its pattern ID

VI.4.2 Linking the patterns to goal graphs

Once the patterns are all identified with pattern identification numbers, their association to the goal graphs becomes much easier. At this time, there are several problems that require attention. First, we may find out inconsistencies in the goal graphs as the graphs do not represent a way of making the links to design patterns appropriately. Second, we may discover patterns that duplicate techniques from other patterns. Third, some operationalizations may not lead to specialized patterns, as the patterns may be represented in a fashion that does not completely match the needs of our goal graphs.

It is imperative that proper attention be paid to the fact that not every node in the goal graphs is going to have an associated pattern. I shall discuss the techniques for addressing these issues in section VI.4.3.

Let us consider figure VI.12 once again, but this time, we will try to make a connection between the goal graph and the design patterns. To make it easier, let us also consider figure VI.7 in conjunction to how it is considered as a design pattern in section VI.4.1. It can be determined that figure VI.7 shows a portion of a generalized design pattern, with reference to specialized patterns such as G94, G92, and G74. And since the pattern in figure VI.7 is in generalized form which refers to guideline 1.1.1, it has been assigned a pattern ID of 1.1.1 (as proposed in section VI.4.1). Using this mechanism, we can label the perceivability of non-text component goal in figure VI.19 with a reference number of 1.1.1. Since the convention is to indicate the topic of the non-functional requirements within squared brackets, such brackets cannot be used for linking the design patterns. Thus, I am going to use curly braces for this purpose.

Further down in the goal graph, we can see that most of the corresponding design patterns match with the operationalized goals, with the exception of a few. Let us consider the ones that match first, and then we shall go over the exceptions. The goal of providing a short text description in figure VI.19 refers to the technique number G94 in WCAG 2.0's guideline 1.1.1. We can use this technique to label the appropriate goal graph with the technique number. By this means, we are essentially creating a link between the patterns and goal graphs which can be used by designers using the goal graphs get to a specific solution.

Since there are many patterns that can be present for each guideline, there needs to be a status-tracking mechanism to indicate which patterns have already been linked. I am going to use a simple checkmark technique. It is demonstrated in figure VI.18. The objective is to mark the items that have been linked already. That way, in the end, some items will surface that will reveal inconsistency or error in the linking.

Continuing to link the graphs to the design patterns while marking the linked patterns in the guideline (as shown in figure VI.18) surfaces the fact that G95and G82 have not been linked. Note that these are the same nodes of the graph that I created in section VI.2 by combining two matching goals. It seems that the techniques for providing the short description may be different when they are used solely for describing non-text items, than when they are used in conjunction with long description for describing non-text items (refer to figure VI.19). Eliminating such issues is a topic that is covered in section VI.4.3.

Situation A: If a short description can serve the same purpose and present the same information as the non-text content:

1. ✓ G94: Providing short text alternative for non-text content that serves the same purpose and presents the same information as the non-text content using a **short** text alternative technique listed below

Situation B: If a short description can not serve the same purpose and present the same information as the non-text content (e.g. a chart or diagram):

1. ? G95: Providing short text alternatives that provide a brief description of the non-text content using a **short** text alternative technique listed below **AND** one of the following techniques for **long** description:
   - o ✓ G92: Providing long description for non-text content that serves the same purpose and presents the same information using a **long** text alternative technique listed below
   - o ✓ G74: Providing a long description in text near the non-text content, with a reference to the location of the long description in the short description
   - o ✓ G73: Providing a long description in another location with a link to it that is immediately adjacent to the non-text content

Situation C: If non-text content is a control or accepts user input:

1. ? G82: Providing a text alternative that identifies the purpose of the non-text content using a **short** text alternative technique listed below
2. Using HTML form controls and links (future link)
3. ✓ H44: Using label elements to associate text labels with form controls (HTML)
4. ✓ H65: Using the title attribute to identify form controls when the label element cannot be used (HTML)
5. Using (X)HTML according to spec (future link)

. . .

Figure VI.18: Placing checkmarks on the patterns that have been linked

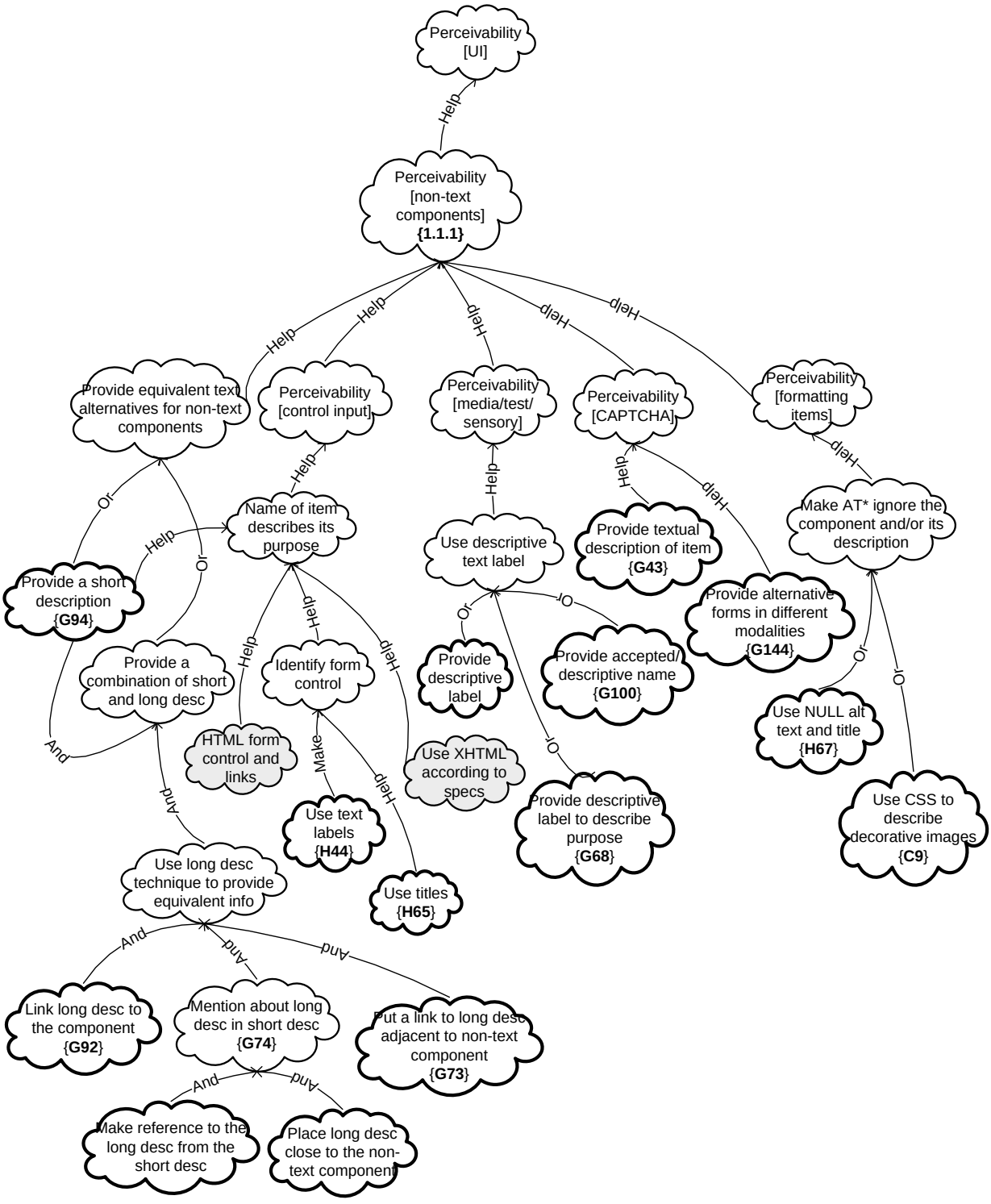


Figure VI.19: A goal graph with links to the appropriate design patterns

VI.4.3 Optimizing the goal graphs, patterns and their linking

At this point, the goal graph can be analyzed further to see what errors, inconsistencies, and ambiguity exists in the linking. This requires close observation, and there is no given technique that can be used to do these. It can however be argued that checking for consistency (such as whether all operationalized goal graphs have a corresponding specialized pattern) will surface a few issues, and perhaps that is where the process should be started from.

In the previous section, I have discussed how the goal graphs and design patterns can be linked together for demonstrating the ways of achieving a goal to the designers. I have noted the possibilities of errors and inconsistencies in the linking between the goal graphs and design patterns. It may not be a straightforward approach as it is difficult to get a good understanding of the complex relationships in the guidelines represented in a textual format. I shall now demonstrate on a few techniques that can be used to help minimize such issues.

VI.4.3.1 Minimizing inconsistencies

Let us first start by looking at inconsistencies. At this stage of the research, it may not be possible to provide a proven technique in determining inconsistencies. However, I shall look at a possible inconsistency for demonstrating how to minimize that.

In figure VI.19, notice how the operationalizations of “make reference to the long desc from the short desc” and “place long desc close to the non-text component” have one common pattern. These two goals are the operationalizations of “mention about long desc in short desc”. That is where the reference to the pattern is at the moment. This can be considered as an inconsistency in two ways. First, it is inconsistent in how the reference to the specialized pattern is being made here. The reference is made from a node of the graph which is not an operationalization. In other cases, it is being made from a node

which is operationalized. Second, this specialized pattern is dealing with two problems – making reference to the long description from the short description, and placing the long description close to the non-textual content. It may be expected that a specialized pattern should deal with one problem at any one time.

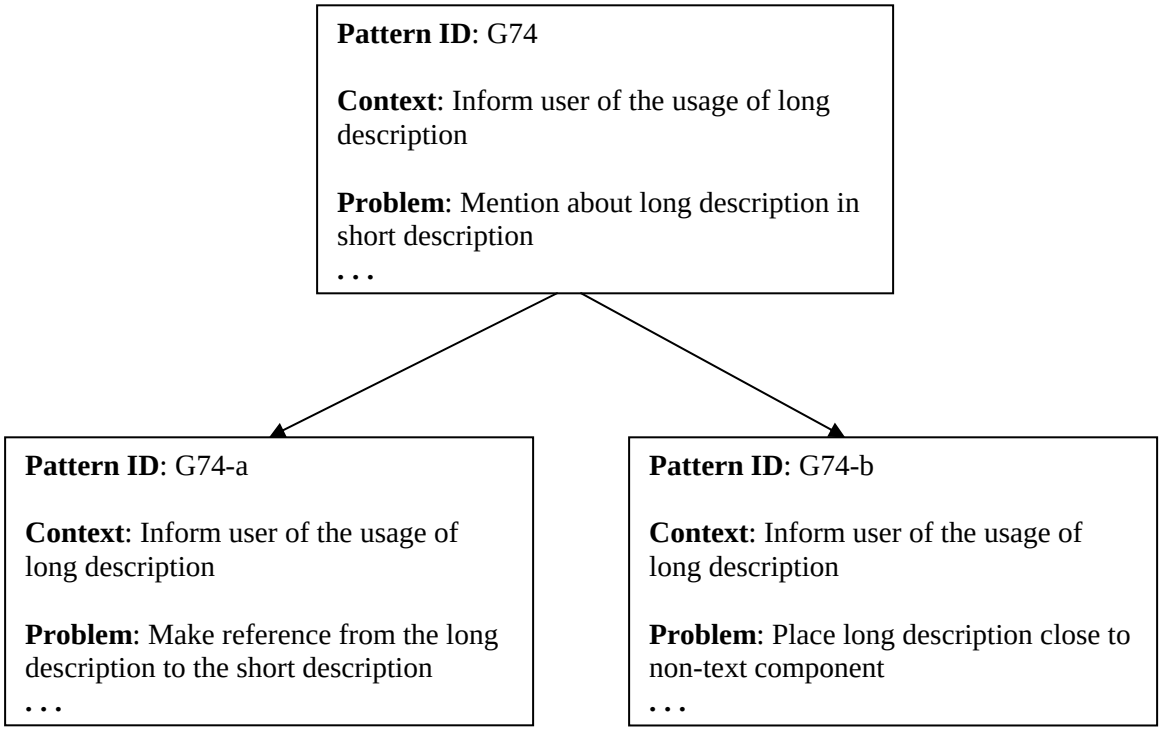


Figure VI.20: Conceptual view of decomposition of a specialized pattern into two further specialized patterns

The inconsistencies that I have just pointed out are not errors, and so do not mean any threat to the overall mechanism of the patterns. However, there is a need for a general convention. Several things can be done to make this consistent to other graphs and their links to the design patterns. First, this pattern can be decomposed into two further specialized patterns, which will deal with each operationalization of the goal separately. The actual mechanism in which a pattern can be decomposed and specialized into other patterns is deferred to future work. However, figure VI.20 shows the conceptual view of how this pattern will network with its decompositions. Second, these new patterns will

also be linked from the goal graph, thus making sure that the linking of operationalized goals remains consistent.

After decomposing the specialized pattern, the linking needs to be made from the goal graphs. Using the technique for linking the patterns to the goal graphs discussed earlier, the graph in figure VI.21 can be developed.

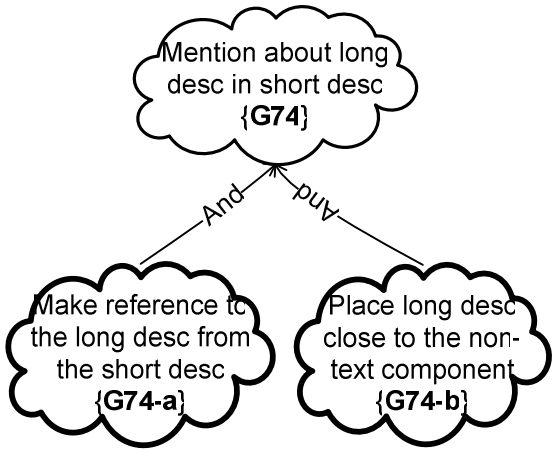


Figure VI.21: Linking the updated design patterns with the goal graph

As mentioned earlier, there is no fool proof way for checking these inconsistencies. However, a thorough checking of the developed goal graphs can possibly provide some good assistance. Since inconsistencies are not errors and fixing them will optimize the ability of the reorganized goal graphs provide focused assistance to the designers, the technique that I just used to overcome the inconsistency should suffice and be effective.

VI.4.3.2 Minimizing errors

Many errors (such as omission and misrepresentation of goals) are likely to surface during the linking process discussed in section VI.4.2. For simplicity, the error that was found in section VI.4.2 (see figure VI.18) will be used for demonstrating the process of fixing the erroneous part of the graph and proper linking between the updated goal graph and design patterns.

Figure VI.18 indicated that there are two omissions in linking the design patterns, since the pattern G95 and G82 have not been linked to the goal graph. Rather, in their place, pattern G94 has been linked to the graph. In such a case, a plausible reason may be that the goal graph conveys a different message than what the original guideline intends to. At this point, a closer reading of the guideline is necessary. Let us consider the three techniques (G94, G95, and G82) below.

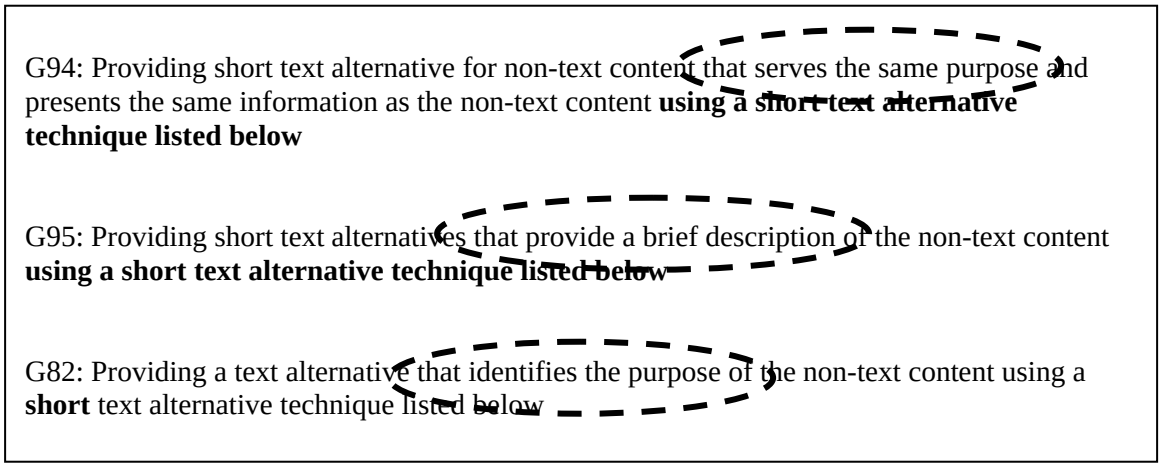


Figure VI.22: Comparing techniques G94, G95, and G82

Notice the circled parts in the techniques. While in G94, the main goal is to have the short text alternative serve as a textual equivalent, it is only meant to provide a brief description in the case of G95. And in the case of G82, it is only meant to identify the purpose of the non-text content. That means, there is a difference in goals, and thus they are given different identification as different techniques. And this difference in goal is certainly of great importance for the goal-oriented approach. However, notice how all three techniques mention the use of short text alternative “listed below”. It turns out that the technology specific techniques for providing a short text alternative are actually listed together at a later part of the guideline, and the designers are required to choose the technique based on the choice of technology they have. Not only that, it turns out that for providing long text alternatives, a technology specific technique needs to be used. The techniques involved are included in figure VI.23.

Short text alternative techniques for use in sufficient techniques above

- H36: Using alt attributes on images used as submit buttons (HTML)
- H37: Using alt attributes on img elements (HTML)
- H35: Providing text alternatives on applet elements (HTML)
- H53: Using the body of the object element (HTML)
- H52: Using the body of the applet element (HTML)
- H24: Providing text alternatives for the area elements of image maps (HTML)
- Providing text alternatives for strings where look-alike glyphs are used in place of letters (e.g. leetspeak) (future link)
- Providing text alternatives for ASCII art (future link)

Long text alternative techniques for use in sufficient techniques above

- H45: Using longdesc (HTML)
- H53: Using the body of the object element (HTML)
- H52: Using the body of the applet element (HTML)

Figure VI.23: The technology specific techniques for providing short and long text alternatives (Caldwell et al., 2007a)

Looking at the descriptions of patterns G95, G94, and G82, it is clear that one might have difficulties in reading the guidelines that are presented in natural language. There needs to be a syntax using which one can determine the necessary details about the guidelines. It is of great importance that the guidelines are presented in a fashion that is easier to grasp. In such a case, I shall demonstrate on how this will be represented using the goal graphs quite appropriately. It is shown in figure VI.24.

Figure VI.24 only presents the modified portion of figure VI.12. It now includes the goals for technology specific techniques for providing short and long text alternatives. Notice how these two goals contribute two other goals for helping them with the technology specific technique.

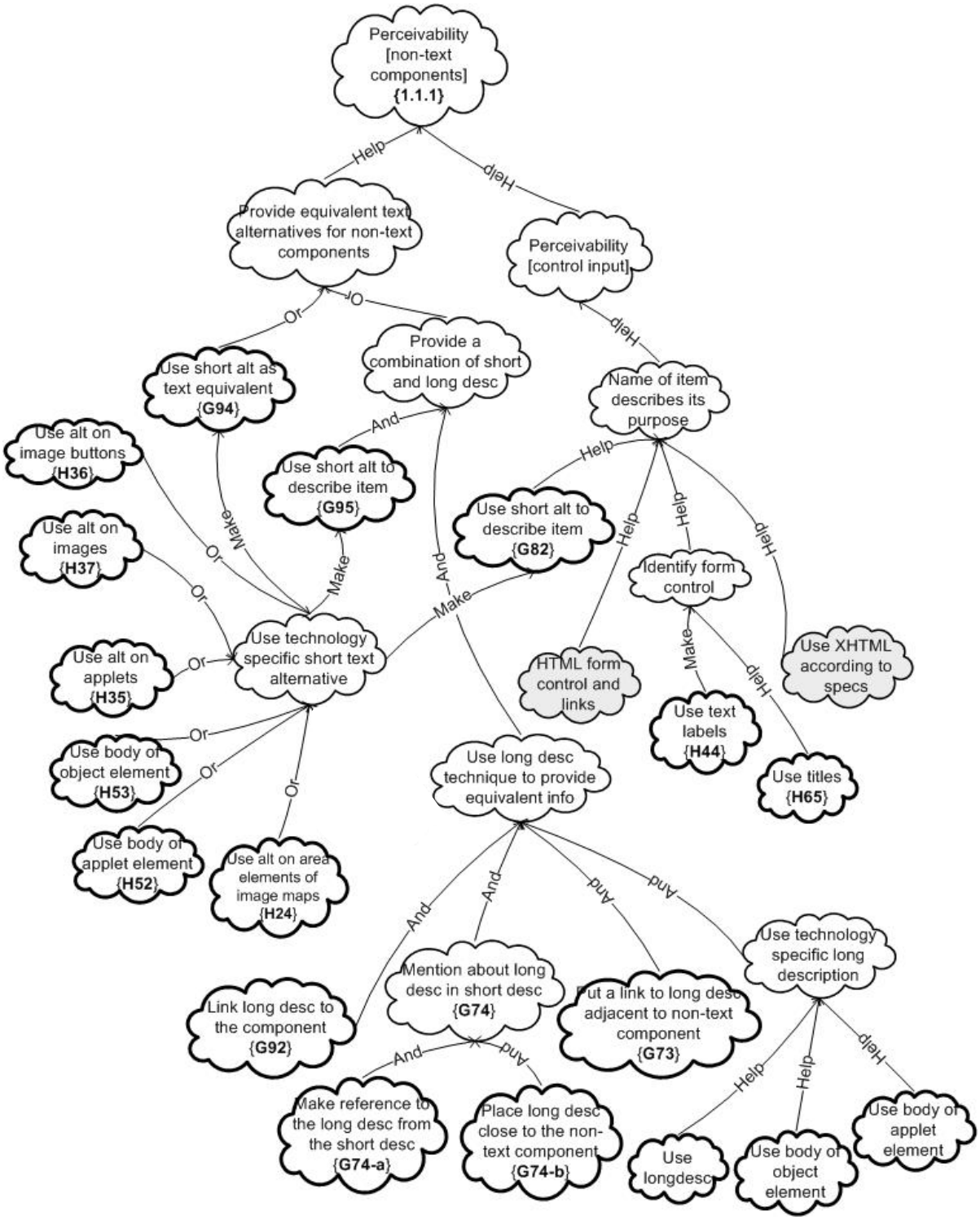


Figure VI.24: A goal graph demonstrating the links to patterns on how to provide short text alternatives

Chapter VII: Applications of the reorganized goal graphs

A review of the literature indicates that there has not been visual representation or modeling of accessibility guidelines before, and thus their inclusion in system and interface design has not been considered before. The use of these the current guidelines in making appropriate interface design is completely based on the designer and the technique s/he chooses to use.

In this chapter, I shall try to demonstrate the number of opportunities that representation of accessibility guidelines using goal graphs will bring into system and interface design. Since this is a first attempt, most of the techniques will be new, and can be expected to have some limitations. I shall discuss the advantages and disadvantages of using these techniques.

VII.1 Using goal graphs for applying guidelines in interface design

Since the goal graphs represent the guidelines more visually than the bulky textual version of the guidelines, their usage in applying the guidelines in interface design is expected to be easier. In this section, I shall introduce a strategy for using the representations developed in the previous chapter. I shall do this by first introducing a very simple sample user interface design, and giving a brief analysis of the design. Following that, I shall introduce a proposed approach in using the goal graphs to apply the guidelines in making the design accessible.

For this case, consider the scenario where a bank is trying to implement an online banking system[17], where the customers will have to sign up online for getting access to their account. Certainly, of primary importance is for the customer to prove his/her identity due to security reasons. The designers have analyzed the functional needs of the system, and come up with a sample user interface as shown in the following.

Figure VII.1: A simple user interface for signing up for online banking

This simple design consists of a few input boxes, where the required input is identified by the text before the input box. There is a button to start the sign up process.

Consider that the designer is applying the guidelines for making the interface perceivable to disabled users. To analyze what is required for making the design perceivable to the disabled users, the designer brings in the perceivability goal graph developed in chapter

[17] Some ideas for this case have been adopted from the Masters thesis by Vilen (2006). Vilen's study involved the accessibility evaluation of Nordea Netbank, one of the first online banking solutions in the world.

VI. Thus, the interface and the goal graph, both being visual representations, are being brought together side-by-side for a detailed analysis of the requirements. This is shown in figure VII.2.

As mentioned in section III.4.3, for applying the accessibility goal graphs in designing a user interface, I am going to use two types of links. They are the APPLIES TO and UNABLE links. The APPLIES TO link is going to point from a specific goal within a goal graph to the interface in hand indicating that this goal applies to the specific interface item. The UNABLE link is used in the same manner, and it is used to indicate that the goal is unable to be applied for the interface item in hand. Refer to appendix B part II for the notations.

In figure VII.2, notice the way the connection is made between the perceivability graph and the actual interface design. This maps the different types of guidelines to the respective items in the interface. The APPLIES TO link is used to convey the message to the item to which the guideline applies to and should be considered for checking and applying the necessary guidelines.

One can use the goal graph in figure VII.2 to reason on which goal is applicable to the design in hand. For example, perceivability in this case refers to the need of the system to define the necessary non-textual items of the page to the users. Since the only non-textual components in figure VII.1 are the input items (text and button), the only relevant goal in this case is “perceivability of control inputs”. It is marked with A in the diagram. Note that A, B, and so on are labels used for explanation only, and are not part of the notation.

The reasoning in figure VII.2 is guided by following the HELP link to this goal graph. It is indicated in the graph that to achieve perceivability of control inputs, the name of the item has to describe its purpose. This is marked with B in the diagram. To achieve this goal however, notice the way that the HELP contribution link guides the designer to find the relevant operationalizations. The goal graph indicates that four goals that are to be met to meet this goal. They are:

- Use short text alternative to describe the item (marked C in the goal graph)
- Use HTML form control and links (marked D in the goal graph)
- Identify the form control (marked E in the goal graph)
- Use XHTML according to specifications (marked F in the goal graph)

Since WCAG 2.0 is still under development, the use of HTML form control and links, and the use of XHTML according to specifications has not been implemented yet. Thus, I shall avoid their use for this demonstration. However, for traceability purposes, it is important to make note of such occurrences. This is a situation where the goal evaluation technique provided by the NFR framework (Chung et al., 2000) can be utilized. Thus, I shall mark these two unoperationalized goals as undecided (using the notation that resembles a question mark with a dot on top of it) as indicated in figure VII.2 in the areas marked D and I. This will enable the designer to revisit the design at a later date and trace back the issues using the goal evaluation.

Using the HELP contribution link to the goal marked B in figure VII.2, the goal graph indicates that a short text alternative needs to be provided for describing the input items (marked C in the figure). This tells the designer that pattern G82 is relevant to this case. However, it further indicates using an AND link that a technology specific technique needs to be used for implementing the alternative text (marked G in the figure). Here, the designer is given a choice on the technique to be applied. This is indicated using the OR links from the graph marked with G. But there does not seem to be any guideline (or specialized pattern) that matches the need of the designer to use an alternative text on input items. This indicates that there does not seem to be an operationalization for the goal marked G that applies in this case. This is indicated using the UNABLE link from the goal graph to the input items. And using the goal evaluation technique, I shall mark it with an X, which indicates that operationalization of this goal has been denied.

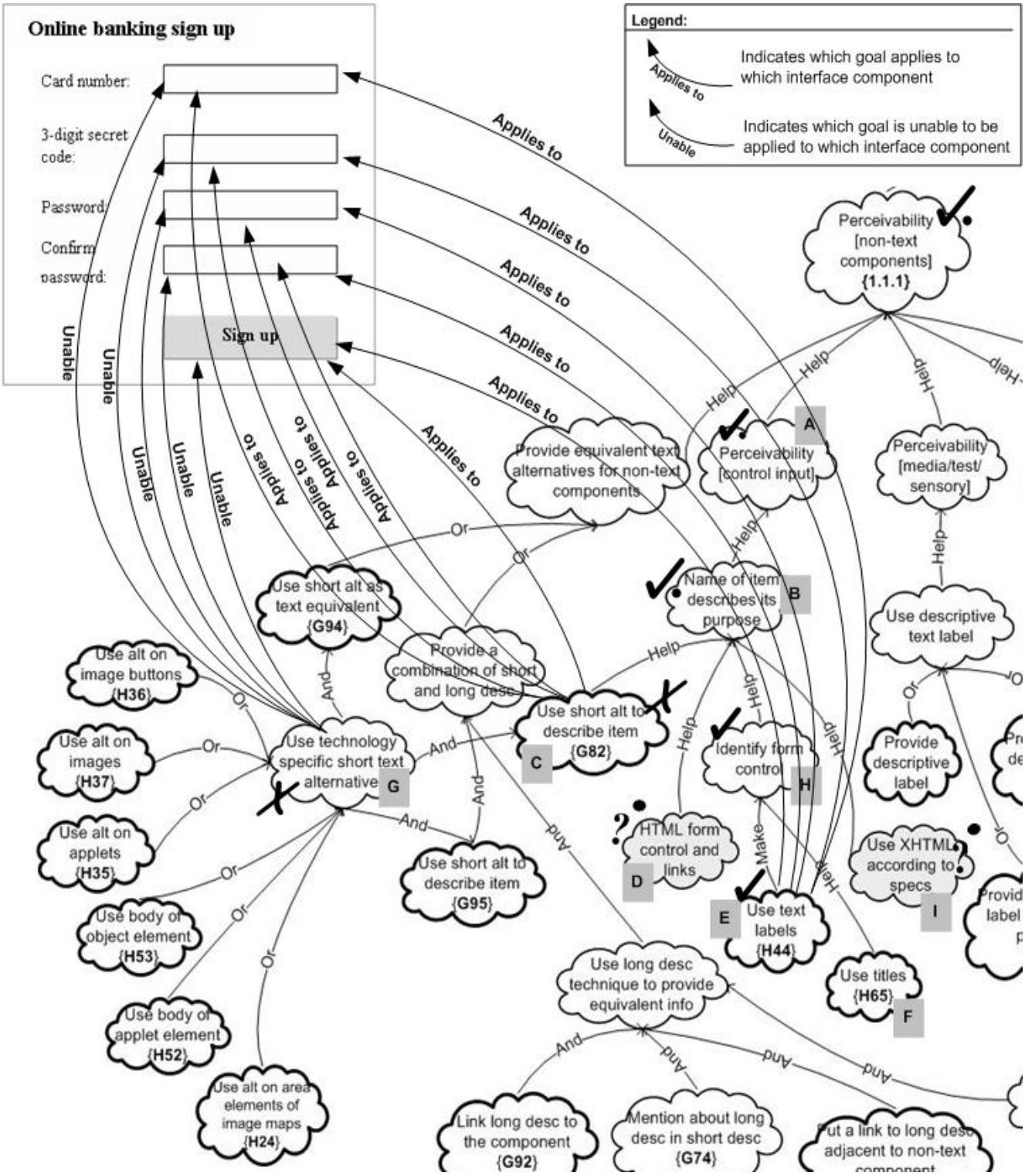


Figure VII.2: Demonstrating a simple application of the perceivability goal graph

The goal marked H has two operationalizations, E and F. Notice how E and F contribute to operationalize H. Goal E contributes with a MAKE link to H, while goal F contributes with a HELP link. This indicates that out of E and F, goal E provides a better alternative than goal F for operationalizing goal H. Thus, it suggests the use of goal E whenever possible, and goal F if goal E cannot be satisficed. Since the sample interface has input items designed using HTML, it is possible for us to operationalize goal H with E. Thus, goal E has been applied in this case to operationalize goal H.

The advantage of applying the goal evaluation technique (discussed in section II.2) provided by the NFR framework in this situation is that this evaluation can be taken further by propagating the evaluation to check whether the goal has been satisficed or not.

Using the goal evaluation technique, it can be seen that even though figure VII.2 indicates that the guidelines marked with C applies to the input items, it still requires that G is satisficed for C itself to be satisficed. The AND link from G to C imposes this constraint on C. Thus, C has been denied from being implemented. This is indicated in the figure in the same way as it appears for G.

The evaluation of the goals that have been applied can be propagated systematically to check whether the top goal has been satisficed or not. For the goal marked B, it is necessary that all the other goals that help in achieving this are satisficed first. It seems that only one is achieved (marked H through propagating the evaluation of C), one has been denied (marked G), and two remain undecided (marked D and I). Using these evaluations, it seems that B has only been weakly satisficed. This is demonstrated (using the satisficed notation with a dot under neat it) on B. The evaluation of B has been further propagated to evaluate A. Since B has only been partially satisficed, A also gets partially satisficed through propagation of goal evaluation.

As mentioned earlier, WCAG 2.0 is a principle oriented guideline. One can thus take this advantage of the guideline to fill its gaps and apply that in the design process. In figure

VII.2, the goal marked in G has not been satisficed due to its inability to be applied in the current context. Figure VII.3 shows how this can be done. Notice the updated goal graph with an additional goal marked J. For simplicity, I am numbering this with pattern ID H36-a. This is an operationalization for G, and is added with an OR link to G. The OR link is used in this case to retain the reasoning of the original goal graph. That way, this updated goal graph can be utilized the designers for future reference.

With the updated goal graph in figure VII.3, it is now possible for the goal marked with G to have an operationalization that applies to the input items. Note the way the link from goal G is gone, and how the goal J has the APPLIES TO link to the applicable items. It is important to note that this APPLIES TO link is not coming from goal G since goal J is more specific to the needs of the sample interface. Furthermore, none of the other operationalized goals in this graph applies to the interface. But in figure VII.2 the UNABLE link has come from goal G as it is this goal that is the most applicable.

Once that goal J in figure VII.3 satisfices the needs of the sample interface, it can be evaluated using the goal evaluation technique. Thus, the evaluation needs to be updated from that of figure VII.2. This has been indicated with the satisficed symbol. This evaluation shall also get propagated to goal G and C. However, goal B does not get affected by this and remains as partially satisficed since it still requires goal D and I to be satisficed before it can be fully satisficed.

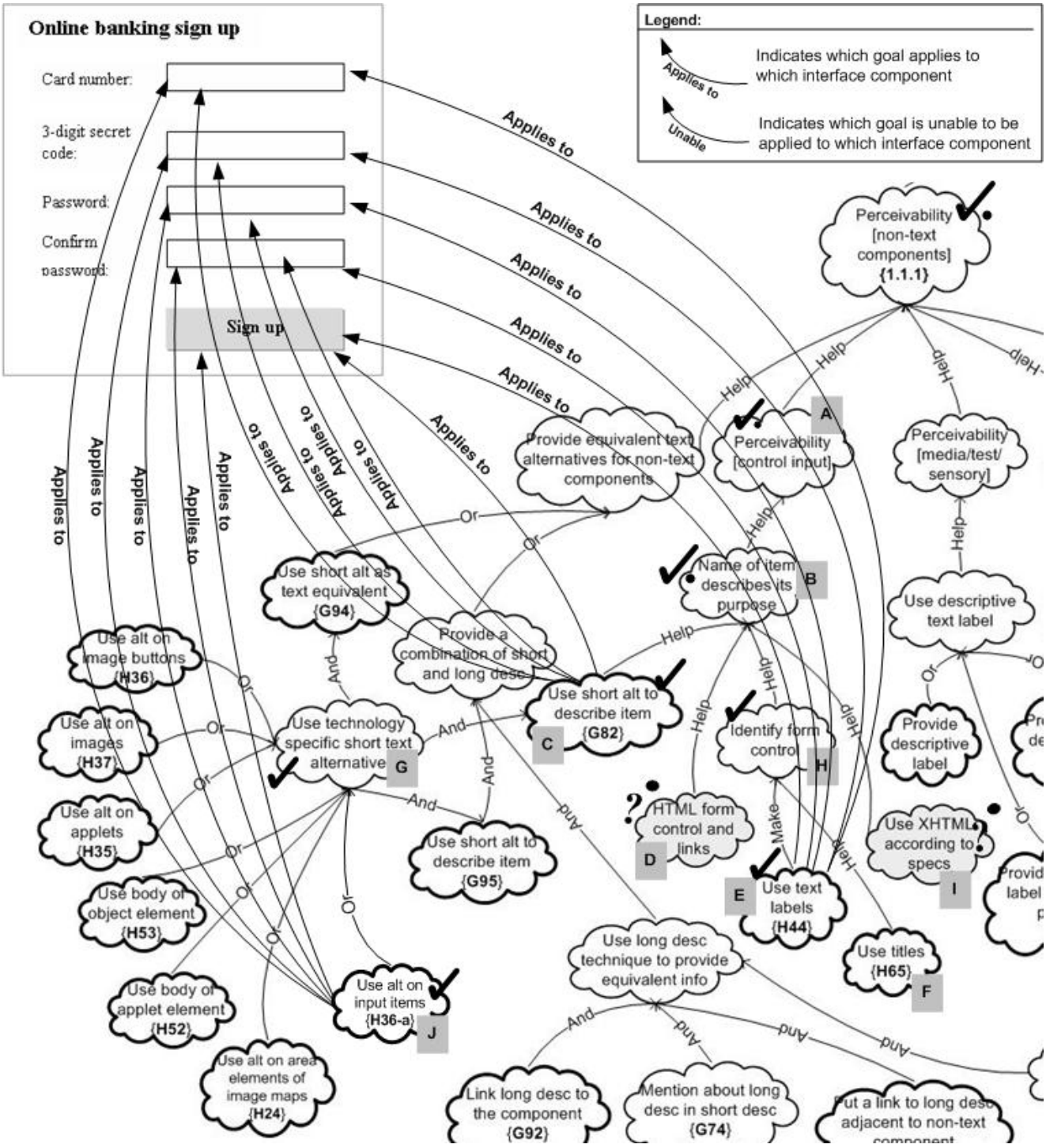


Figure VII.3: Demonstrating a simple application of the perceivability goal graph

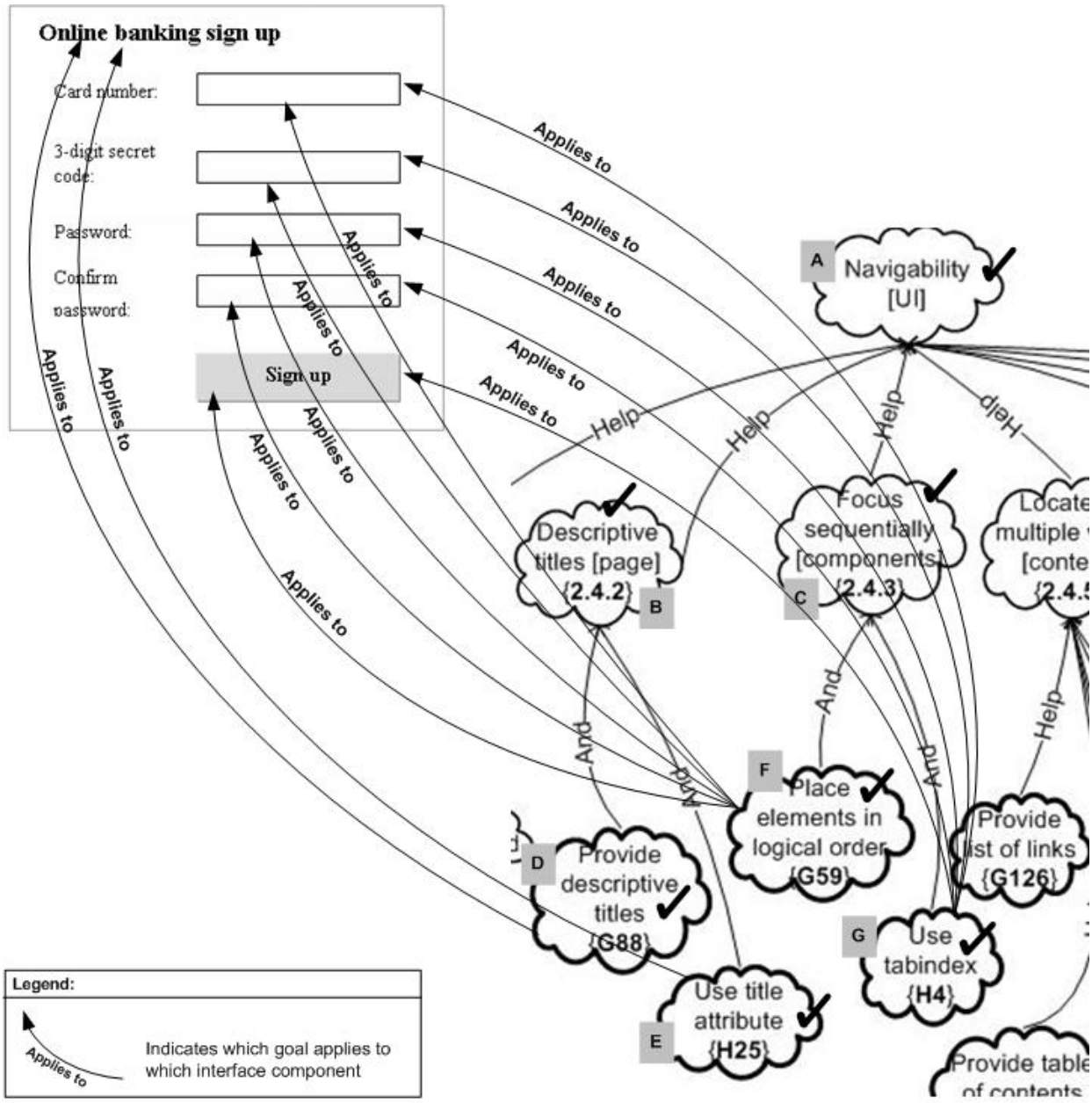


Figure VII.4: Demonstrating a simple application of operability goal graph

Using the technique discussed thus far in this chapter, the goal graph application in figure VII.4 has been done. It attempts to make the connection between the operability goal graph with the sample interface. The applicable goals have also been evaluated. Note that goals marked D and E are operationalizations for goal B, they are linked to B with AND links. Similarly F and G are operationalizations for C, and they are linked to C with AND

links. Thus, B and C have been evaluated as satisficed by propagating their corresponding operationalizations (D and E for B; F and G for C) that have been satisficed.

The application of the goal graphs that I have demonstrated so far only relates to the use of one goal graph at a time that represents part of the guidelines. However, as I have noted earlier, accessibility is not necessarily a yes or no answer where the mechanism for making web site contents accessible is a straight forward approach. It is important to analyze the approaches for providing accessible web contents along with other competing goals. In the next section, I shall demonstrate a process in which the system goals can be analyzed together with accessibility goal graphs and their application in designing accessible web contents.

VII.1.2 Integrating the guidelines into system design

The use of goal graphs in goal oriented modeling allows us to make non-functional requirements explicit and make use of them in the design process. Using the goal graphs used in the NFR framework, it is possible to analyze goals that may compete with each other. Through this analysis, designers can make design decisions by evaluating the competing goals and their operationalizations. This analysis may also be used as a possible technique for taking the kind of holistic approach suggested by Kelly et al. (2004).

In the previous section, I have demonstrated a proposed technique for applying the reorganized guidelines with a sample interface. This reorganization of the guidelines allows us to bring the guidelines into a representation using the goal graphs, which opens up the opportunity for the analysis of these guidelines with other system goals. In this section, I shall demonstrate the method for this goal analysis and evaluation.

As mentioned earlier, system goals are often competing and they conflict with other goals. Consider the example of security as a system goal where the designers have chosen encryption as a technique for solving the security problem. But applying encryption technology will have some impact on the efficiency of a system since encryption technologies require additional computational power.

Let us consider a more relevant example, where the application of the reorganized accessibility guidelines can be seen. Consider that a small organization has a web site where they are planning to web-cast a live event. For this, they are using the following sample interface.

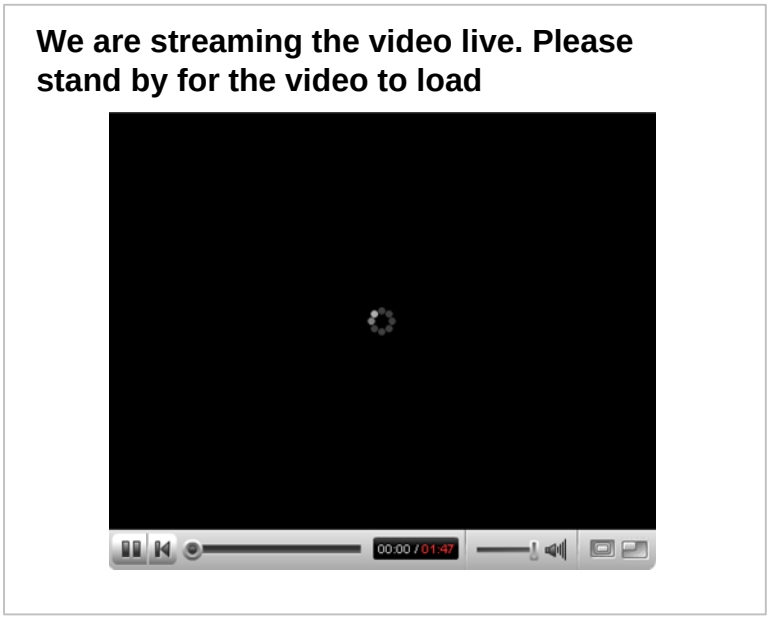


Figure VII.5: A sample interface for web-casting a live event

For making the sample interface above perceivable, the designer has to introduce the guideline number 1.2.3 from WCAG 2.0. This guideline is shown in figure VII.6. For

simplicity, I am considering only the specific portion of the guideline applicable in this scenario.

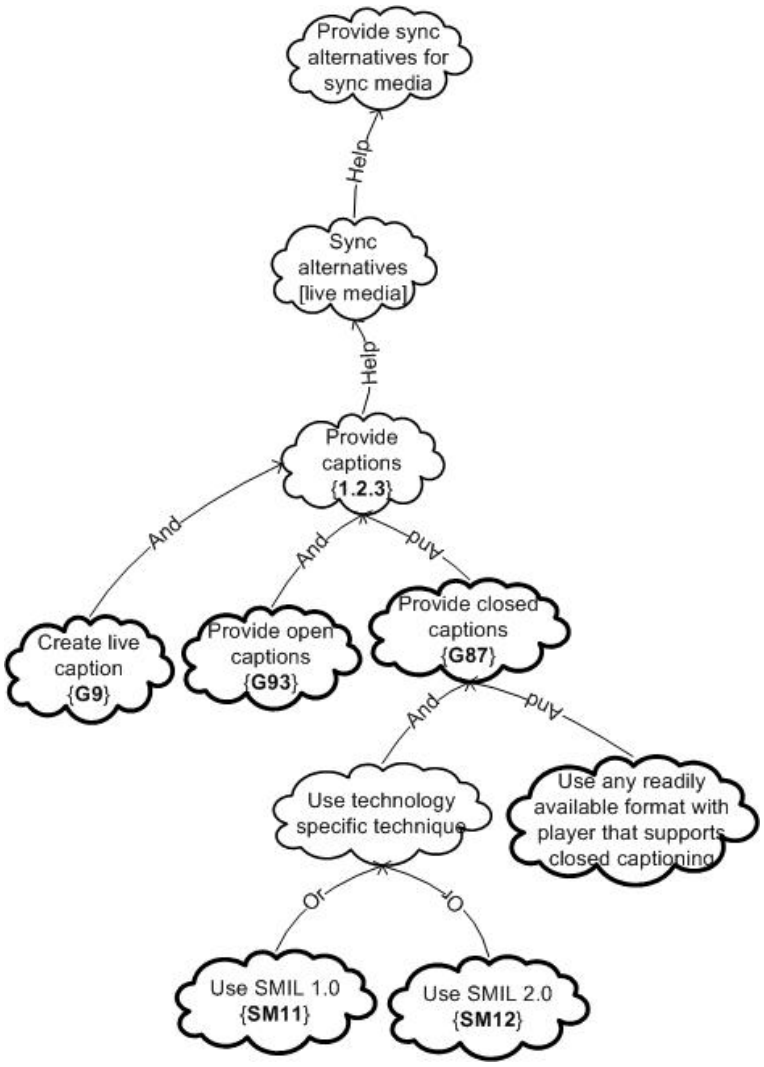


Figure VII.6: Goal for perceivable live contents

The guideline in figure VII.6 indicates that the designer is required to provide both open and closed captioning. It suggests that closed captioning be done using either SMIL 1.0 or 2.0, and any other readily available format with player. The applicable nodes of the goal graph have the pattern links.

Even though the organization is able to provide live web-cast of an event due to the minimal expenses required for web-casting the event, it cannot however afford to hire a web maintenance staff on a full-time basis for providing live captioning of the event. Furthermore, the organization has decided to reduce its expenses for operating the web site on a regular basis by performing web maintenance only when the staff are available. These constraints are indicated in the graph in figure VII.7.

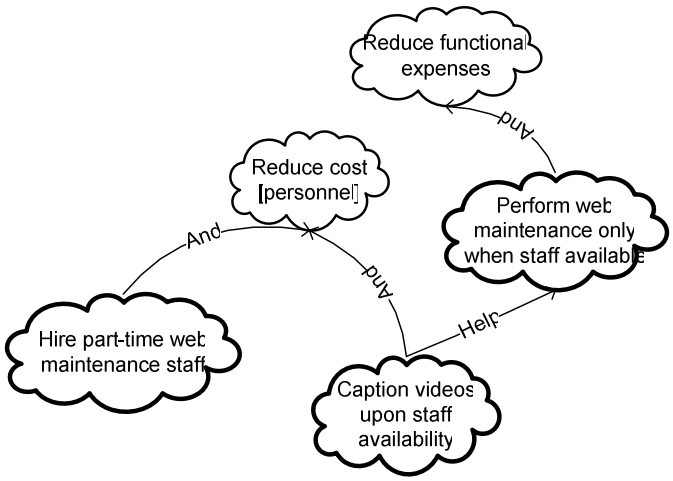


Figure: VII.7: Cost limitations imposed on the web design

These considerations for the sample web contents can now be systematically analyzed together to check for the conflicts and consistency among the goals and the interface design. Figure VII.8 shows this interaction among the goal graphs and how it can be applied into the sample interface. Notice that even though the goals marked D, E, and F apply to the interface, goal F cannot be operationalized due to the constraints imposed by goal H. Since goal C refines into three mandatory goals using the AND link, all their operationalizations must be met before C can be satisficed. However, it can be seen that the situation still allows for the expertise to provide captioning in general. As it is not possible to provide captioned live synchronized media, goal F is denied from being implemented, and goals D and E are weakly denied from being implemented. Their evaluations are propagated to the goal C and above.

The goal evaluation and application showed in this case can also be considered a little differently by providing further refinement of goal marked B in figure VII.8. This has been done in figure VII.9 where the refinement of goal B is goal L. This goal indicates that by changing the needs of providing live captioned web-cast to a recorded media with captioning, it is still possible to achieve certain level of accessibility. It further indicates that goal L can be achieved with the current expertise of the organization's web maintenance staff.

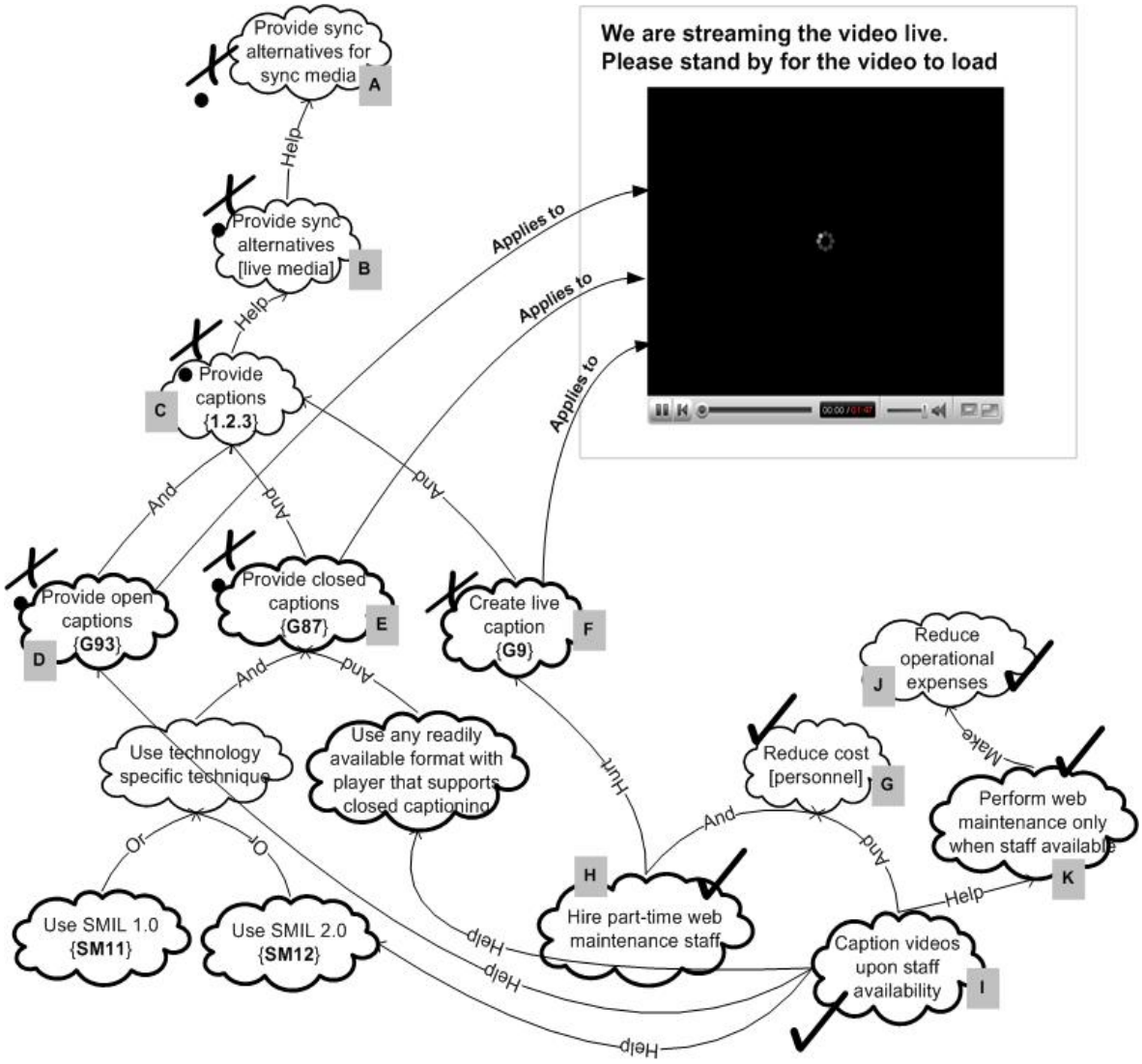


Figure VII.8: Evaluation of the accessibility goals along with cost reduction goal

This example has considered a very simple situation by applying relevant goal graphs to make design decisions and evaluate them appropriately. The analysis provided in figure VII.9 indicates the difference in the outcome of the analysis than in figure VII.8. In figure VII.8 goal A has been weakly denied due to the system constraints, while in figure VII.9 the same goal has been weakly satisficed in an attempt to at least make the site contents more perceivable to the disabled users.

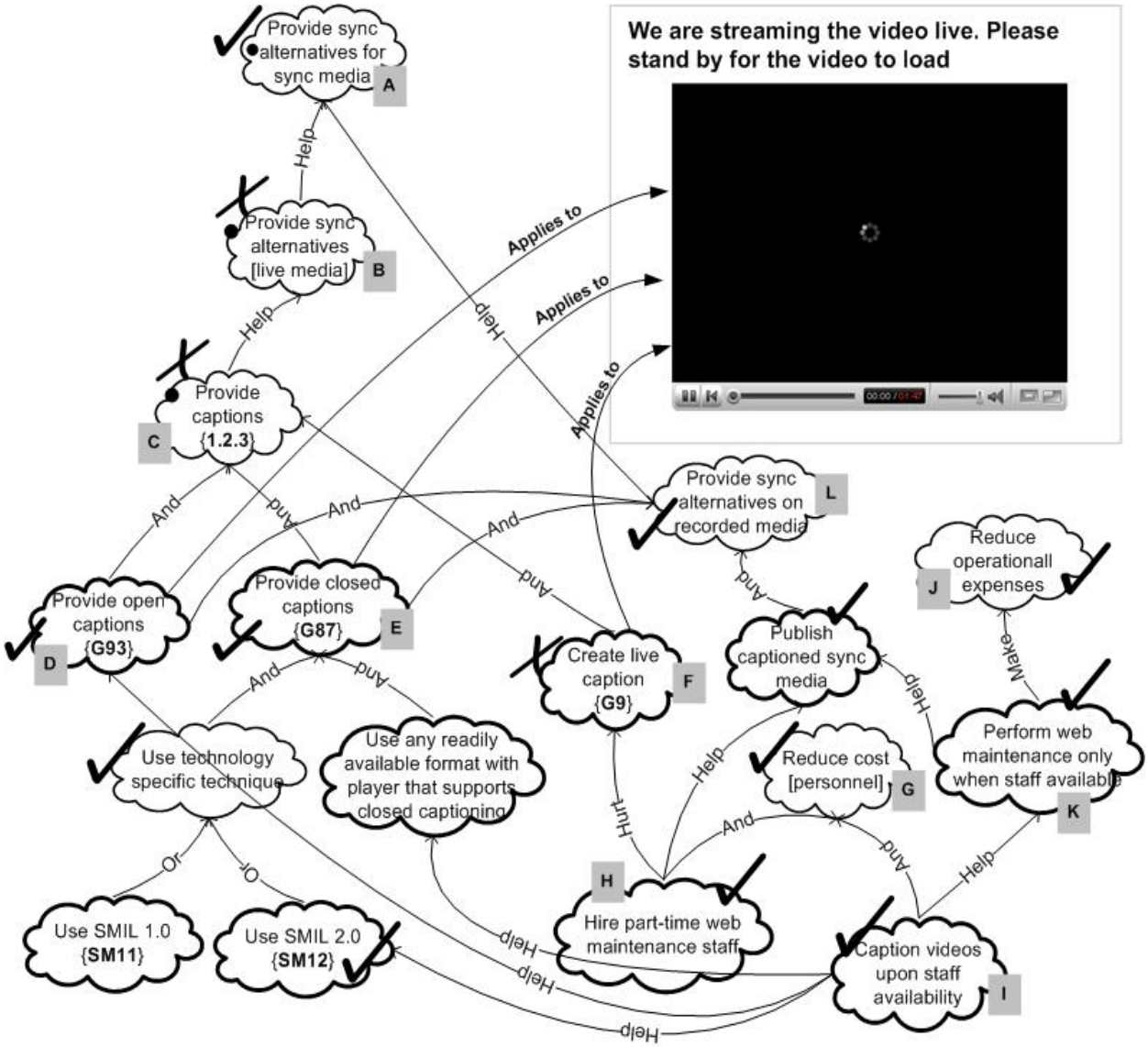


Figure VII.9: Satisficing the accessibility goals along with cost reduction goal using alternative techniques

VII.1.3 Performing accessibility evaluation using goal graphs

Evaluation of web pages to check their conformance to accessibility guidelines is a task that many designers have to perform on a regular basis. So far, a few techniques have been developed for performing such tasks. A widely used technique is the one using WCAG 1.0 checklist, which consists of a linear sequence of checkpoints that web developers have to conform to for making accessible web contents. Other evaluation techniques include automated evaluation tools that go through the web contents and automatically analyze the contents for their conformance to accessibility guidelines. So far, there seems to be only one tool that does this evaluation using WCAG 2.0.

Regardless of the technique that designers use, there are many things that can only be checked for using manual evaluation techniques. I have discussed these approaches in the literature review.

In this section, I shall introduce a proposed technique in which accessibility evaluation can be performed using the reorganized accessibility guidelines. Technique will make use of the goal graphs in a way that will enable designers to not only find the problems, but also find the appropriate solution to the problems using the design patterns. I shall use the sample interface that I used for the online banking case earlier in this chapter. See figure VII.1 for the sample interface. I shall also use the operability goal graph developed in chapter VI. It can also be found in appendix C.

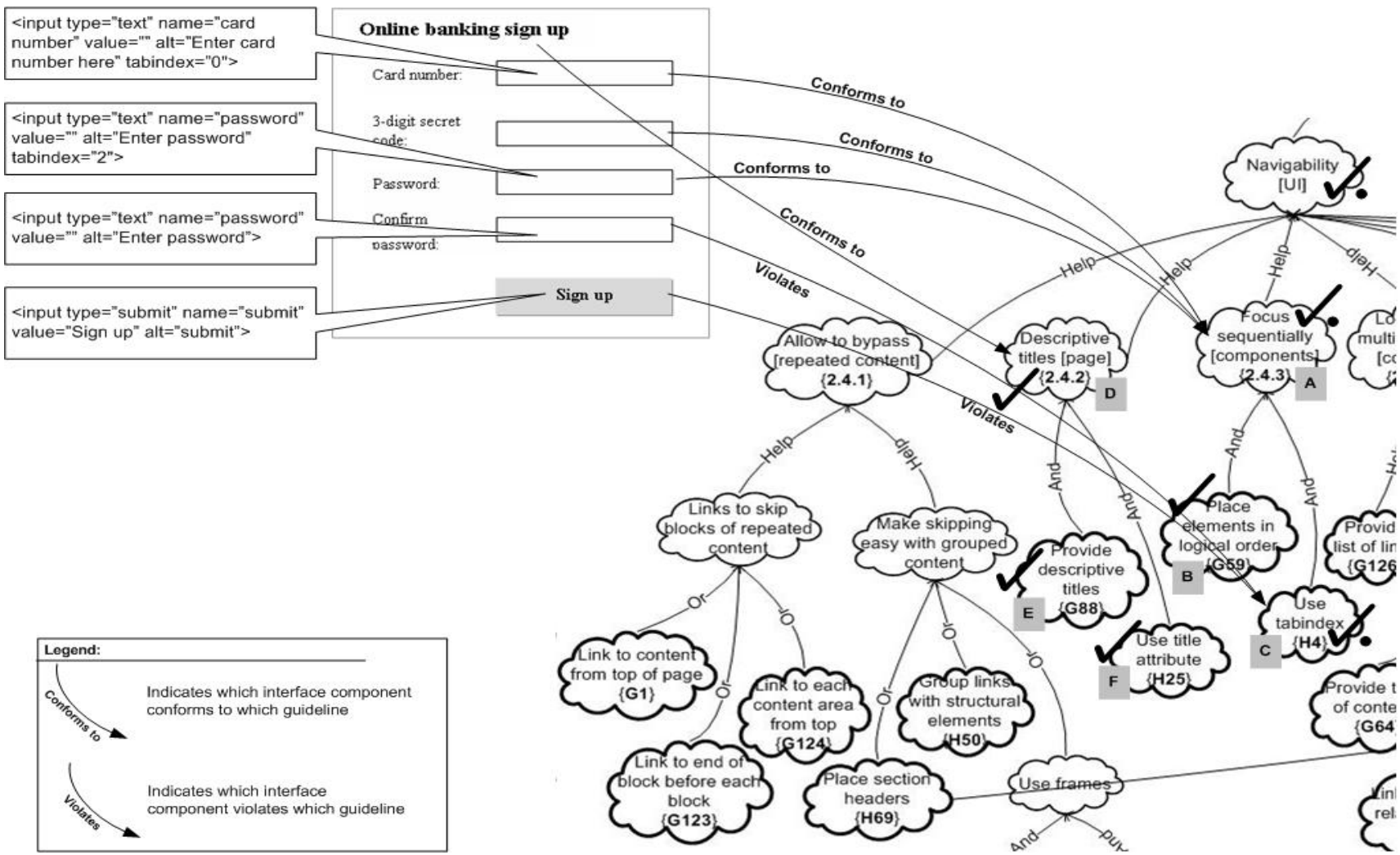


Figure VII.10: Using the navigability goal graph for performing accessibility evaluation

It is necessary that a notation be used in performing the evaluation. In section III.4.3, I elaborated on the use of the CONFORMS TO and VIOLATES links. The CONFORMS TO link points from the interface item to the specific goal in the goal graph. This is going to indicate that the item is in conformance to the specific accessibility goal. The VIOLATES link is going to work in the same manner, except that it is going to indicate that the item is in violation of the specific accessibility goal. These notations are listed in appendix B part II.

Figure VII.10 demonstrates the evaluation of the online banking signup interface using the operability goal graphs. For the appropriate interface items, it is necessary to point out the HTML codes that have been used for the items. This is going to make identification of the problem easier. I have used callouts in figure VII.10 for showing the associated HTML code.

At this point, the reorganized guidelines can be systematically applied for performing accessibility evaluation on the sample interface. The CONFORMS TO and VIOLATES links are going to be connected from the specific interface items to the appropriate nodes in the graph that the component conforms to or violates. However, attention must be paid to the way in which these links are used. There is a subtle difference in their usage.

In figure VII.10, notice the way that the card number field in the interface is linked to the goal marked with A using a CONFORMS TO link. Notice that A has two refinements, B and C, connected to it using AND links. By using pointing the CONFORMS TO link to goal A, it is implied that the input box for card number conforms to both goal B and goal C. However, the VIOLATES link from the confirm password input box goes directly to goal C. In this case, it is pointing at the specific guideline that this interface violates. This way, the designer can make note of the specific issues at hand, and deal with the evaluation of the goal graph appropriately by allowing traceability of the reasons behind the evaluation.

VII.2 Case study: eHealth

To show the effectiveness of the techniques used in the previous section of this chapter, I shall now demonstrate the technique for an eHealth case. This is not only going to show the effectiveness of the technique in using accessibility guidelines, but also show how the technique can help take a more detailed approach by holistically analyzing and evaluating other competing system goals.

In this section, I shall first describe the domain of the case. I shall then introduce a very important requirement for the eHealth case. By analyzing the goal, it is going to be clearer on the types of problems that one may run into if the accessibility guidelines are not applied in conjunction with the other system goals. I shall then demonstrate how the system goal can be combined with the accessibility guidelines and applied systematically for the case. I shall then produce a modified interface, which I will evaluate using the guidelines and the system goals.

VII.2.1 Description of the domain and interface

The domain of eHealth (electronic health) is fast advancing, where the public health is making changes in the way care is being provided to the patients. More and more, initiatives for creating eHealth systems for providing electronic health records (EHR) to the patients are taken (CHI, n.d.). This has the potential to keep patients more organized by keeping track of their health records. It provides the security against losing medical records, and also allows the patients to access it any time they want (CHI, 2007). Furthermore, EHRs make it easier for patients to be diagnosed away from their local health care providers.

An important issue that can been questioned repeatedly is the risks involved with putting electronic records on the health care providers' web sites. These risks are related to allowing

patients to view the patient records for treating themselves. Thus, if the patients treat themselves based on the information on the web site, it is very important that the patients are provided with the correct and unambiguous information. Otherwise, EHR projects can run into serious issues related to safety of patients.

Following is a sample interface of an EHR that can potentially be presented to a patient. It has been taken from the Canada Health Infoway's (CHI) report on Corporate Business plan for 2006-2007 (CHI, n.d.). The interface is presented in a way as it can be potentially presented in a web based environment. Note that this is for illustration purposes only, and that it is not intended for an actual UI design.

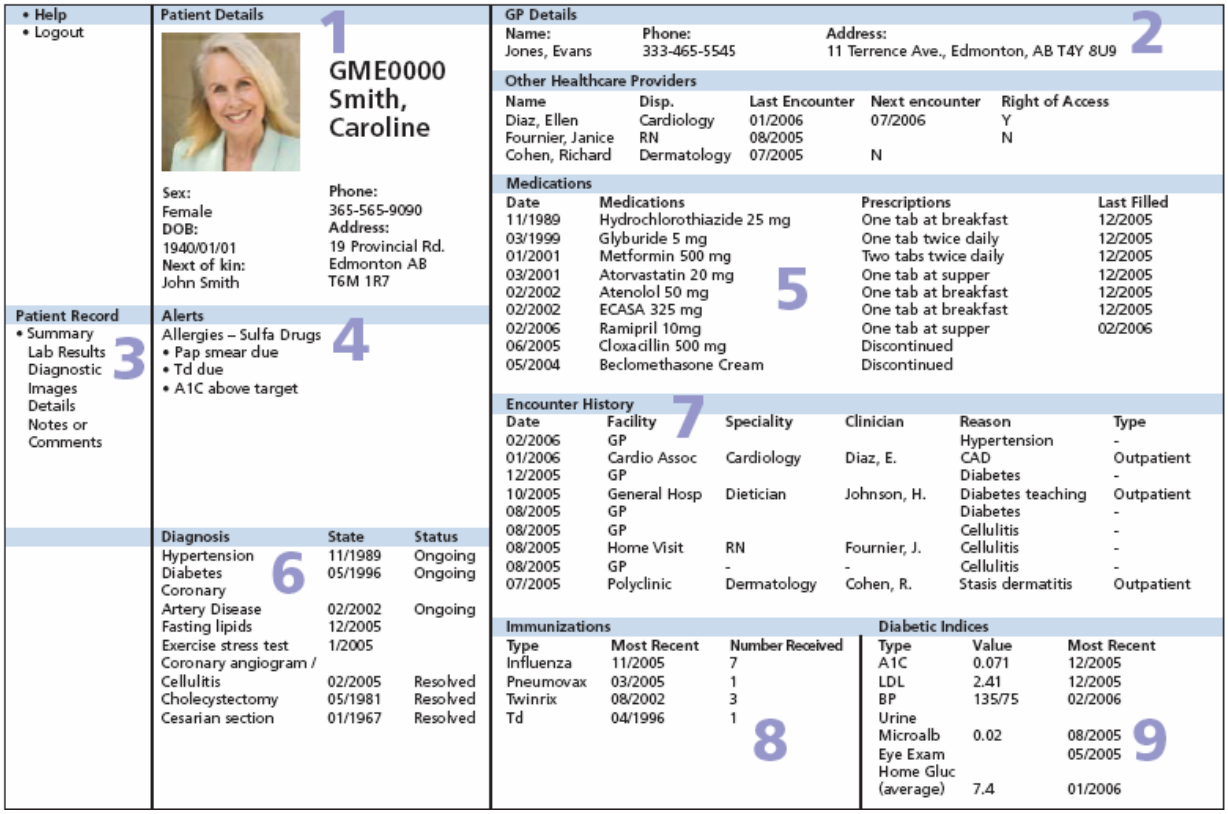


Figure VII.11: The user interface of a possible eHealth system (CHI, n.d., p 7)

The marked areas in the in figure VII.11 represent the following information (the number represents the number in the figure) (CHI, n.d., p 7).

1. Demographic information of patient: identifies the patient
2. Primary clinician and other healthcare providers' information: provides the details about the patient's primary care giver
3. Laboratory results, images and hospital clinical reports: identifies these results and reports for the patient
4. Alerts: provides the patient alerts for allergies and other issues that require immediate attention
5. Medication history including dosage recommendations: provides these important history of the patient, as it can be used in taking medications in case of emergency
6. Medical history/problem list: provides the medical history for referring back to past history
7. History of interaction with the healthcare system: provide information on hospital and clinic visits
8. Immunization history: provides the dates and other information regarding the patient's immunization history
9. Patient's chronic disease history: shows an example of how the EHR can be extended for providing patient specific information

The amount of details provided in the sample interface shows that any misleading information can prove to be detrimental for patients. For example, a telehealth patient can be quite dependent on the information provided in their EHR. Any misinterpretation of the data can lead to wrong self-treatment for the patient, which includes wrong medication. On the other hand, any delay in presenting the necessary information to the patient can be damaging to the patient's health in case of emergency. I shall discuss these issues in further detail in the next section.

VII.2.2 Safety: an important requirement for eHealth records

Patients can be at risk if any of their health data in the EHR leads to wrong or late treatment due to misinterpretation or improper navigation of the health data. Thus, safety of patients is a goal that needs to be included in the system design. By doing so, its implications in the web design should also be considered appropriately. For performing an analysis of patient safety as it relates to the system and its interface, the goal graph in figure VII.12 can be used. Note that this goal graph is just a sample representation of a possible situation, and does not go over the vast detail that a real case might entail. It is only meant for illustration purposes.

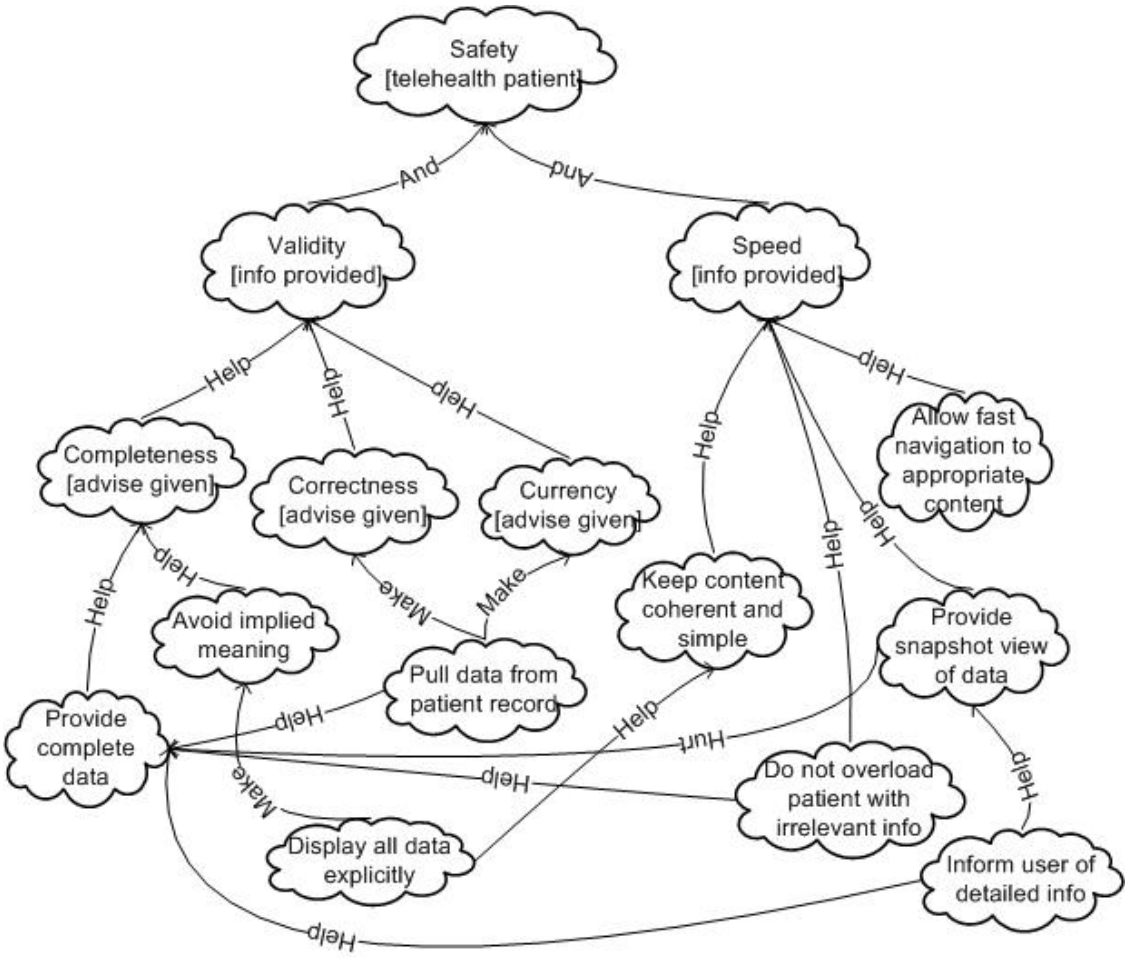


Figure VII.12: The goal graph that relates to patient safety in an eHealth situation

In figure VII.12, it can be seen that the top goal is the safety of a telehealth patient. This has been refined into the validity of the patient data, and the speed in which the patient is provided with the health data on the eHealth site. It can be seen that validity of the online data also depends on their completeness, correctness, and currency. To help with completeness of the health data, it is important to provide complete data and avoid implying a meaning by not stating something explicitly. Completeness of the health data can be based on the ability of the eHealth system to provide the data by directly taking it from the patient records.

To allow patients the ability to find their health information fast, the eHealth system is required to provide the content in a coherent way so that the user does not have to adapt to the design of the web page every time the page changes. Furthermore, putting too much unnecessary information will require the user to read more before s/he can find the intended information. By providing a snapshot view of the data of a patient, much information can be provided quickly. However, patients should also be given the opportunity to get detailed information about specific areas of their EHR.

VII.2.3 Application of the guideline and other goals

Now that the goal for safety of the patients has been made clearer through the goal graph, it can be applied to the design to see how its application is able to find the accessibility concerns for the sample web interface. For this section, I am going to use two accessibility goal graphs – for navigability and understandability. Both these goal graphs have been provided in appendix C.

Figure VII.13 shows the application of the navigability goal graph along with the safety goal graph developed in the last section. Both these are then applied to the interface design. This application makes use of the technique discussed in section VII.1.1. Notice that the goal marked I is being helped by organizing a page using headers (marked H). Since H is the

operationalization of goal G, goal G is applied to the part of the interface where no apparent section header is being used. Satisficing goal G helps achieve goal I (which is to achieve the ability of navigating to the appropriate content). Similarly, goal C is used for allowing skipping of content from sections to sections. Since no breadcrumb trail is being used in this design, users may find it difficult to understand their exact location. Thus, goal D should be achieved by providing a breadcrumb trail.

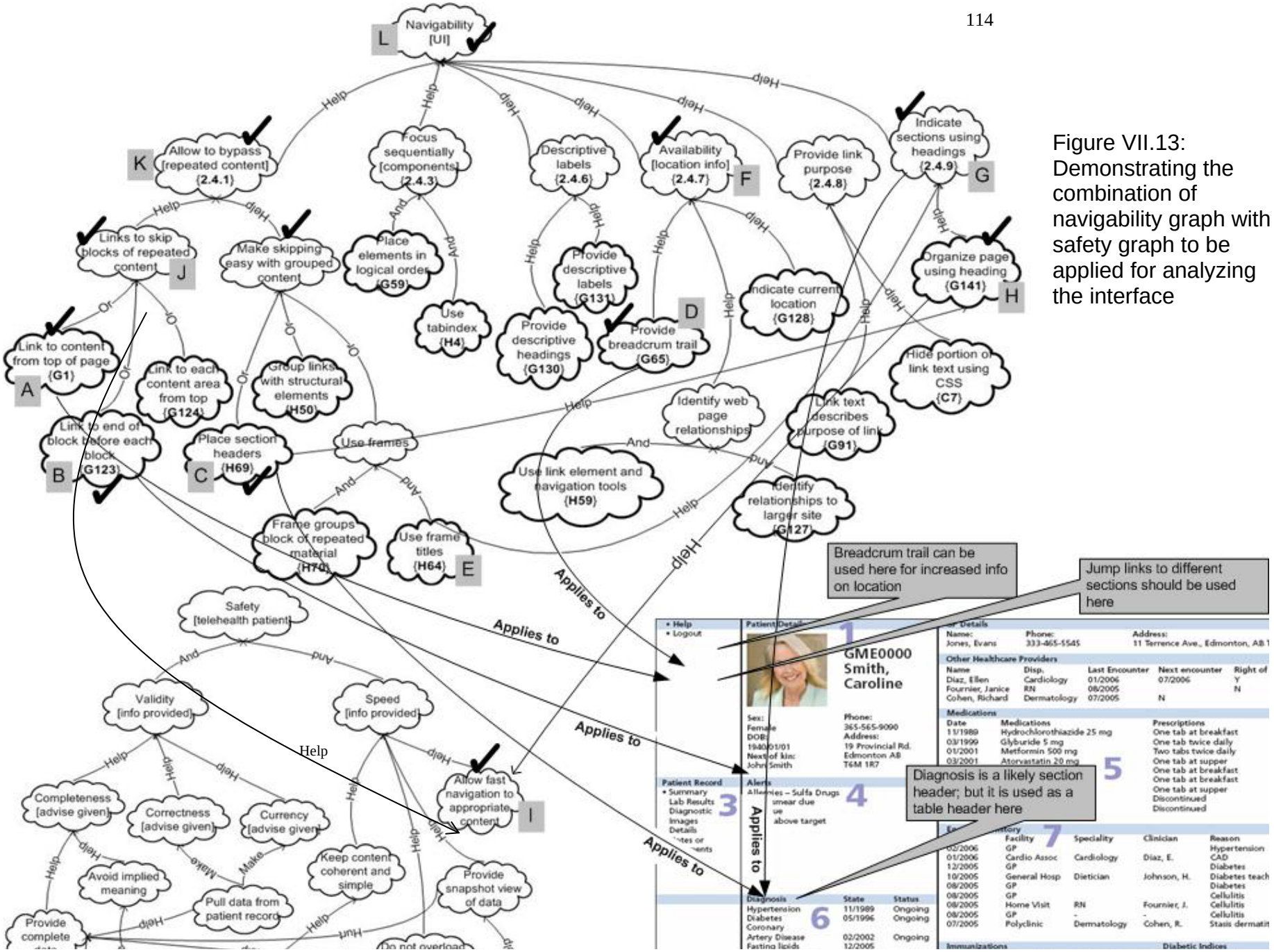


Figure VII.13: Demonstrating the combination of navigability graph with safety graph to be applied for analyzing the interface

In figure VII.13, operationalization of goal J has been done a little differently than the conventional way. Goal J has three alternatives, and two of the alternatives have been used. The reason is, since operationalization of goal J will help goal I. Since goal I is to provide faster navigation, operationalizing both goals A and B might provide more alternative ways for navigation than just one method.

The left side of figure VII.14 shows the application of principle 3.1 of WCAG 2.0 in the form of goal graph. This goal is to provide the web contents in an understandable manner. Notice how the goal of safety is being applied in this case. Goal C helps goal W in providing contents in a way that the content does not have any implied meaning. Goal W achieves goal Y by requiring that all data is expressed explicitly. This is a very important issue that must be addressed for making sure that patients are not provided with information that may be interpreted differently. Leaving an empty space to imply that data is not available may not be appropriate. For example, if a user is using a screen reader for interpreting the data, the screen reader will simply skip over this content. A screen reader might read the second last row of the area marked J in figure VII.14 as follows.

> “Date: 06/2005
> Medications: Cloxadllin 500 mg
> Prescriptions: Discontinued
> Last filled:
> Date 05/2005”

Thus, the screen reader does not provide the information about the last filled date by continuing to read the following row as “date 05/2005”. When placed together, there is a possibility that the screen reader will read out the information in the last part as follows: “last filled date 05/2005”. This is misinformation, and can lead to wrong interpretations by the patient.

In the next section, I shall provide a redesigned interface based on the application of the guidelines in this section.

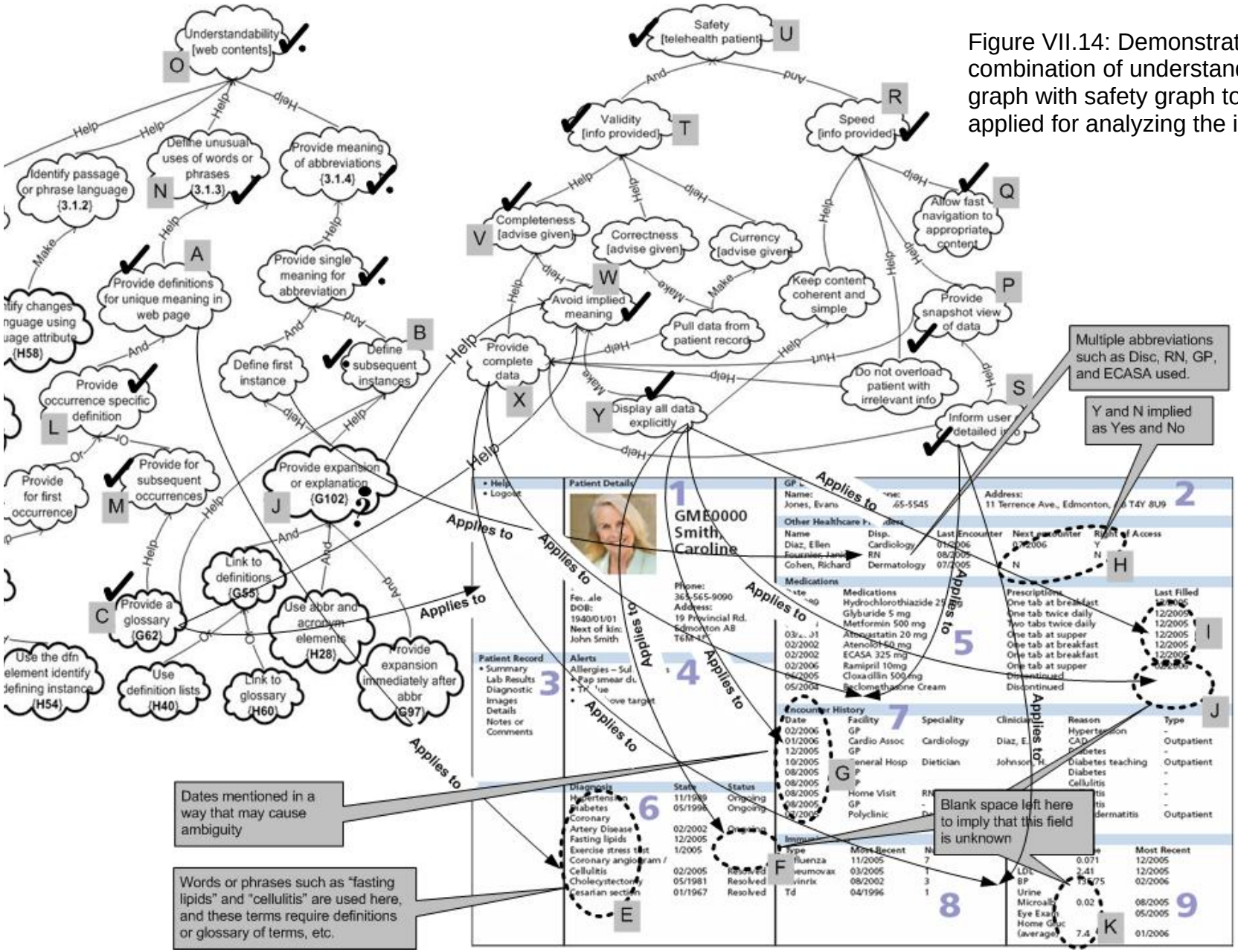


Figure VII.14: Demonstrating the combination of understandability graph with safety graph to be applied for analyzing the interface

VII.2.4 A modified interface

Using the sample interface and the analysis provided earlier in this chapter, a redesigned interface is presented. This interface has the following features.

- There are quick links to each sections that are provided at the beginning of the page
- Two pages for glossary of terms, and abbreviations have been linked to from the main menu of the page
- Breadcrumb trails used to make it easier for users to know about their location
- Beginning of each section has a link enabling them to skip to next section
- Items that were previously left empty to imply a meaning have now been filled with data explicitly mentioning what these spaces represent

After the application of the accessibility guidelines, it has been possible to provide some of the important features to the sample interface. These features are expected to make the page more accessible, and allow better navigation and understanding to all users.

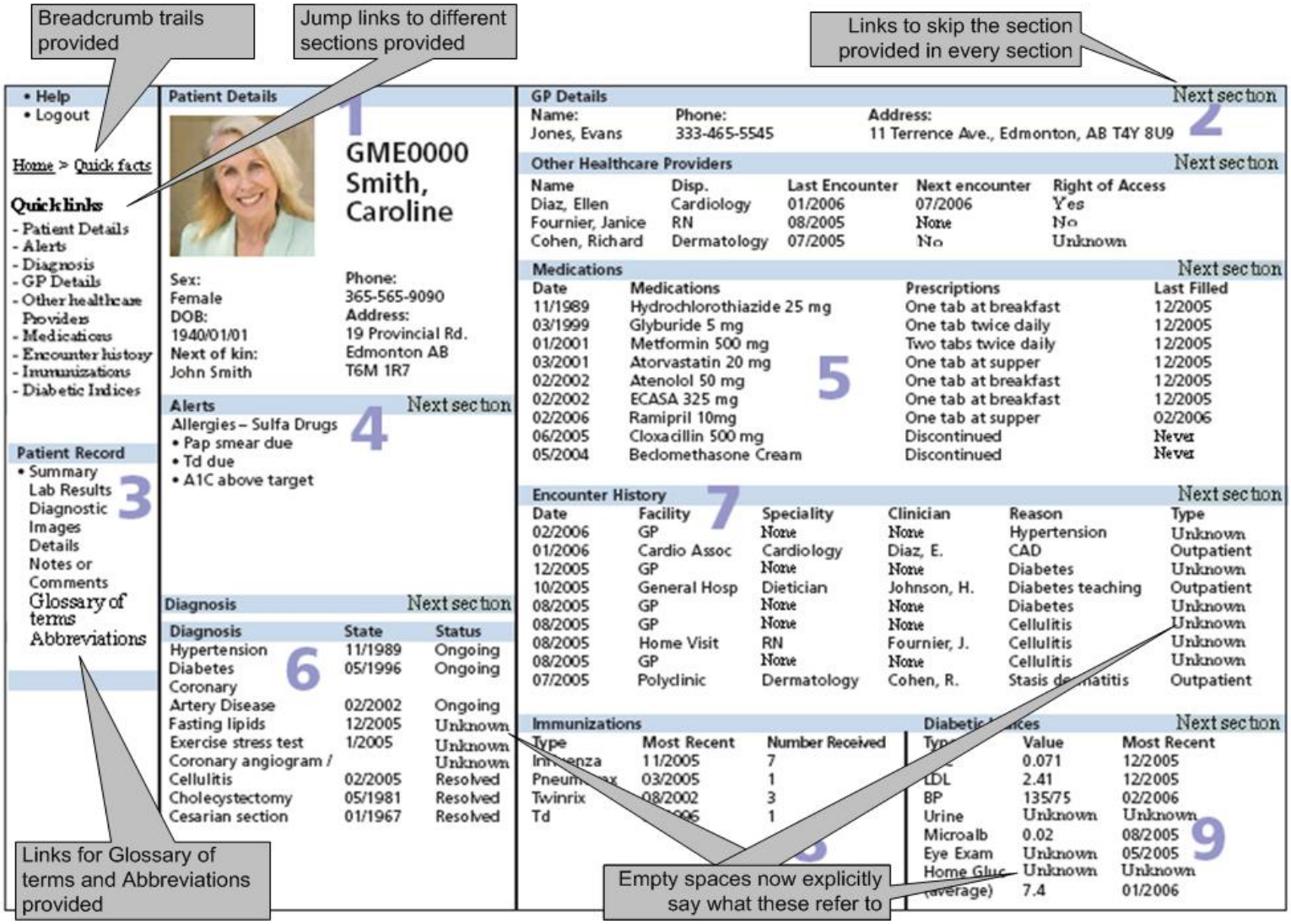


Figure VII.15: The redesigned interface

Chapter VIII: Conclusion

VIII.1 Filling the apparent gap in research

This research started by looking at the difficulties that web designers may face in applying the accessibility guidelines in their work. By identifying possible areas in representation, organization, and usage of the accessibility guidelines, I have proposed a technique for making use of goal graphs and design patterns in making the guidelines more readily applicable, provide better help to the designers, and enable holistic analysis on the user interfaces.

With this work, I have tried to fill an apparent gap in research by taking applicability of the accessibility guidelines a step further. I hope that this work will open doors for more research on applying modeling techniques in designing user interfaces, and in applying goal oriented modeling approach in the design.

VIII.2 Goal orientation in authoring tools

Goal oriented modeling, as I have shown in this research, is able to represent goals graphically, and systematically approach different scenarios. Thus, if the knowledge that is represented in the accessibility goal graphs can be embedded into the authoring tools that web designers use to perform their web designs, it may have a great outcome. For example, if the goal of linking every section of the page from the top of the page for easy navigation is considered, the goals within the authoring tool's knowledge may automatically ask a designer whether s/he wants to embed such mechanism in the design. Another example could be case of a menu, where a designer can create a menu in the web design, and tell the authoring tool that this item serves as a menu. It is possible that the authoring tool does all

the tricks itself based on its embedded knowledge, and makes the necessary changes within the code to make the page more navigable and robust.

To deal with this, developers of the authoring tools can take advantage of the goal analysis, and see how the knowledge from the goal analysis can be embedded within the authoring tools. That way, even if an authoring tool conforms to UAAG 2.0 guidelines, it is possible to make the tool embed a similar knowledge that a designer would have after using the goal graphs developed in this research.

VIII.3 Goal orientation in policy making

Policy making is another area where goal oriented modeling can be useful. Taking the goal oriented modeling, the government strategies for introducing new policies can be first represented using goal graphs, analyzed with any other competing policies, and then evaluated to check whether the policies are at conflict, or whether they are all in agreement. For organizations, their strategies to meet the policies of the government can be represented, analyzed, and evaluated using the goal oriented modeling technique.

The most effective part of the goal oriented modeling technique is that it allows goals to be made explicit, and to be analyzed with other competing goals in a systematic manner. Emphasis must be given on the term “systematic” here, since this, to me, is the most attractive part of this technique.

VIII.4 Future work

The proposed technique may require more analysis and testing for successful adoption by the designers. The following may provide a good foundation for future work.

Additional support: Future research must be performed to determine whether additional support is necessary for reorganization of the accessibility guidelines. Different mechanisms for such reorganization must be tested to determine the best approach.

Dealing with conditions: Currently, goal oriented modeling does not provide support for dealing with conditions. It may be an area where more emphasis can be put, so that conditional statements in guidelines can be represented effectively.

Testing with real designers: The research is only going to make an impact in the design community if the designers are provided with an easy yet effective mechanism for using the reorganized guidelines. Thus, the reorganized guidelines must be tested with real users to see how it is accepted as a possible alternative to using the current textual forms of accessibility guidelines.

Testing with real cases: The technique for applying the accessibility guidelines must be tested using real cases to see the outcome of the technique. More complicated situations must be used than the ones used in this research for finding whether the technique does provide an effective mechanism for detailed goal analysis.

Applicability with different types of users: Not everyone is likely to be able to render the knowledge in models. Thus, reorganizing the guidelines into graphical representations does not necessarily make it easy for the overall design community to be able to use it. Imposing a new representation may simply make using accessibility guidelines more difficult for some. Thus, easy alternatives for using the reorganized guidelines must be evaluated. Current use of

using design patterns with the goal graphs may help solve this issue. However, future research must determine the appropriate level of complexity in which the goal graphs and the design patterns can be combined.

Validity of application: This research indicates that with the application of goal graphs in accessibility research, accessibility goals can be represented, analyzed, and evaluated effectively. At this very early stage of this research, it is important to emphasize that the validity of this application must be checked with real cases and real users, under real circumstances. Once it is checked under such constrains, only then will it guarantee the validity of this application.

References

Adaptive Technology Resource Centre [ATRC]. (n.d. a). Web Accessibility Verifier: Ensuring that your Webpages are Accessible to all People. Retrieved on November 15, 2006 from http://www.aprompt.ca/

Adaptive Technology Resource Centre [ATRC]. (n.d. b). Web Accessibility Checker. Retrieved on November 15, 2006 from http://checker.atrc.utoronto.ca/index.html

Berners-Lee, T. (2002). The World Wide Web – Past Present and Future: Exploring Universality. *Japan Prize Commemorative Lecture.* Retrieved on January 3, 2008 from http://www.w3.org/2002/04/Japan/Lecture.html

Berners-Lee, T. (2005). WWW at 15 Years: Looking Forward. *Proceedings of the 14th international conference on World Wide Web,* 1 – 1. Retrieved on January 3, 2008 from [Login required] http://doi.acm.org/10.1145/1060745.1060746

Brajnik, G. (2004). Comparing accessibility evaluation tools: a method for tool effectiveness. *Universal Access in the Information Society,* 3, 252 – 263.

Buschmann, F., Muenier, R., Rohnert, H., Sommerlad, P., and Stal, M. (1996). *Pattern-Oriented Software Architecture: A System of Patterns.* West Sussex, England: John Wiley & Sons Ltd.

Caldwell, B., Cooper, M., Reid, L. G., & Vanderheiden, G. (2007a). Web Content Accessibility Guidelines 2.0: W3C Working Draft 17 May 2007. *W3C*. Retrieved on September 15, 2007 from http://www.w3.org/TR/2007/WD-WCAG20-20070517/

Caldwell, B., Cooper, M., Reid, L. G., & Vanderheiden, G. (2007b). Web Content Accessibility Guidelines 2.0: W3C Working Draft 11 December 2007. *W3C.* Retrieved on December 19, 2007 from http://www.w3.org/TR/2007/WD-WCAG20-20071211/

Canada Health Infoway [CHI]. (n.d). Getting There – Canada's Electronic Health Record Evolves: Creating Healthy Connections (Corporate Business Plan 2006-2007). Retrieved on November 18, 2007 from http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Business%20Plan%2006-07%20EN.pdf

Canada Health Infoway [CHI]. (2007). Canada's Next Generation of Health Care at a Glance. Retrieved on November 18, 2007 from http://www.infoway-inforoute.ca/Admin/Upload/Dev/Document/Vision_Summary_EN.pdf

Chisholm, W. A., and Henry, S. L. (2005). Interdependent Components of Web Accessibility. *Proceedings of the 2005 International Cross-Disciplinary Workshop on Web Accessibility (W4A)*, 31 – 37. Retrieved on March 25, 2007 from [Login required] http://doi.acm.org /10.1145/1061811.1061818

Chisholm, W. A., Vanderheiden, G., and Jacobs, I. (editors). (1999). Web Content Accessibility Guidelines 1.0. *W3C.* Retrieved September 2, 2006 from http://www.w3.org/TR/1999/WAI-WEBCONTENT-19990505

Chung, L., Nixon, B. A., and Yu, E. (1994). Using Quality Requirements to Systematically Develop Quality Software. *Fourth International Conference on Software Quality.* Retrieved on March 10, 2007 from ftp://ftp.cs.toronto.edu/pub/eric/ICSQ4Paper.pdf

Chung, L., Nixon, B. A., and Yu, E. (1995). Using Non-Functional Requirements to Systematically Support Change. *Proceedings of the Second IEEE International*

Symposium on Requirements Engineering. Retrieved on February 20, 2007 from [Login required] http://doi.ieeecomputersociety.org/10.1109/ISRE.1995.512554

Chung, K. L., Nixon, B., Yu, E., and Mylopoulos, J. (2000). *Non-Functional Requirements in Software Engineering.* Boston: Kluwer Academic Publishers.

Clark, J. (2003). *Building accessible websites.* Indianapolis, Ind.: New riders Publications.

Colwell, C., and Petrie, H. (2001). Evaluation of Guidelines for Designing Accessible Web Content. *ACM SIGCAPH Computers and the Physically Handicapped,* 11 – 13. Retrieved on May 10, 2007 from [Login required] http://doi.acm.org/10.1145/501078.501082

Craig, L. (1998). *Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design.* New Jersey: Prentice Hall.

Cysneiros, L. M., Yu, E., and Leite, J. C. S. P. (2003). Cataloguing Non-Functional Requirements as Softgoal networks. *Proceedings of the REAA Workshop at the 11th Requirements Engineering Conference,* 13 – 20.

Cysneiros, L. M., and Yu, E. (2003). Non-Functional Requirements Elicitation. In J. C. S. P. Leite, and J. H. Doorn (Eds.), *Perspectives on Software Requirements*. United States: Kluwer Academic Publishers.

Dardailler, D., Palmer, S., and McCathieNevile, C. (editors). (2002). XML Accessibility Guidelines. *W3C.* Retrieved September 1, 2006 from http://www.w3.org/TR/2002/WD-xag-20021003

Etre. (2007). Colour Blindness Simulator. *Etre: Do it Yourself.* Retrieved on February 10, 2007 from http://www.etre.com/tools/colourblindsimulator/

Fukuda, K., Saito, S., Takagi, H., and Asakawa, C. (2005). Proposing New Metrics to Evaluate Web Usability for the Blind. *CHI '05 extended abstracts on Human factors in computing systems,* 1387 – 1390. Retrieved on February 14, 2007 from [Login required] http://doi.acm.org /10.1145/1056808.1056923

Gamma, E., Helm, R., Johnson, R., and Vlissides, J. (1995). *Design Patterns: Elements of Reusable Object-Oriented Software.* Massachusetts: Addison-Wiley.

Gross, D., and Yu, E. (2001). From Non-Functional Requirements to Design Through Patterns. *Requirements Engineering,* 6, 18 – 36.

Hackett, S., Parmanto, B., and Zeng, X. (2005). A retrospective look at web accessibility over time. *Behaviour & Information Technology,* 24 (6), 407 – 417.

Hanson, V. L., et. al. (2005). Improving Web accessibility through an enhanced open-source browser. *IBM Systems Journal,* 44(3), 573 – 588.

Horkoff, J. (2006). *Using i* Models for Evaluation.* Masters Thesis. University of Toronto, Canada. Retrieved on January 8, 2007 from http://www.cs.utoronto.ca/~jenhork/MScThesis/Thesis.pdf

Hull, L. (2004). Accessibility: It's Not Just for Disabilities Any More. *Interactions*, 11(2), 36 – 41. Retrieved on March 20, 2007 from [Login required] http://doi.acm.org/10.1145/971258.971270

ISI Web of Knowledge. (2007). Journal Citation Reports. *ISI Web of Knowledge.* Retrieved May 8, 2007 from http://portal.isiknowledge.com /portal.cgi/JCR?Init=Yes&SID=S17EckdhoeGAGBN8K1o

Ivory, M. Y., Yu, S., and Gronemyer, K. (2004). Search Result Exploration: A Preliminary Study of Blind and Sighted Users' Decision Making and Performance. *CHI 2004*

Extended Abstracts on Human Factors in Computing Systems, 1453 – 1456. Retrieved on January 25, 2007 from [Login required] http://doi.acm.org /10.1145/985921.986088

Ivoery, M. Y., and Megraw, R. (2005). Evolution of Web Site Design Patterns. *ACM Transactions on Information Systems,*23(4) 463 – 497. Retrieved on March 20, 2007 from [Login Required] http://doi.acm.org /10.1145/1095872.1095876

Jackson-Sanborn, E., Odess-Harnish, K., and Warren, N. (2002). Web site accessibility: a study of six genres. *Library Hi Tech,* 20(3), 308 – 317.

Jacobs, I., and Brewer, J. (1999). Accessibility features of CSS. *W3C.* Retrieved September 2, 2006 from http://www.w3.org/1999/08/NOTE-CSS-access-19990804

Jacobs, I., Gunderson, J., & Hansen, E. (Eds.) (2002). User Agent Accessibility Guidelines 1.0. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/TR/UAAG10/

Johnson, A., and Ruppert, S. (2002). An evaluation of accessibility in online learning management systems. *Library Hi Tech,* 20 (4), 441 – 451.

Kelly, B., Phipps, L, and Swift, E. (2004). Developing a Holistic Approach for E-Learning Accessibility. *Canadian Journal of Learning and Technology,* 30(3). Retrieved on September 22, 2007 from http://www.cjlt.ca/content/vol30.3/kelly.html

Kelly, B., Sloan, D., Phipps, L, Petrie, H., and Hamilton, F. (2005**).** Forcing Standardization or Accommodating Diversity?: a Framework for Applying the WCAG in the Real World. *Proceedings of the 2005 International Cross-Disciplinary Workshop on Web Accessibility (W4A),* 46 – 54. Retrieved on May 10, 2007 [Login required] http://doi.acm.org/10.1145/1061811.1061820

Koivunen, M., and Jacobs, I. (editors) (1999). Accessibility features of SMIL. *W3C* Retrieved September 1, 2006 from http://www.w3.org/TR/1999/NOTE-SMIL-access-19990921/

Lazar, J., Beere, P., Greenidge, K., and Nagappa, Y. (2003). Web accessibility in the Mid-Atlantic United States: a study of 50 homepages. *Universal Access in the Information Society,* 2, 331 – 341.

Lazar, J., Dudley-Sponaugle, A., and Greenidge, K. (2004). Improving web accessibility: A study of webmaster perceptions. *Computers in Human Behavior,* 20, 269 – 288.

Lazar, J., and Greenidge, K. (2006). One year older, but not necessarily wiser: an evaluation of homepage accessibility problems over time. *Universal Access in the Information Society,* 4, 285 – 291.

Lemon, G. (2006). WCAG 2.0: The difference Between a Level and a Priority. Retrieved on December 10, 2007 from http://juicystudio.com/article/wcag2-difference-between-level-priority.php

Leporini, B., Andronico, P., & Buzzi, M. (2004). Designing Search Engine User Interfaces for the Visually Impaired. *Proceedings of the 2004 international cross-disciplinary workshop on Web accessibility (W4A) W4A '04,* 57 – 66. Retrieved on December 2, 2006 from [Login required] http://doi.acm.org /10.1145/990657.990668

Mak, J. K. H., Choy, C. S. T., and Lun, D. P. K. (2004). Precise Modeling of Design Patterns in UML. *Proceedings of the 26th International Conference on Software Engineering,* 252 – 262.

Mazzocato, G. (n.d.). Accessibility Color Wheel version 1.2. Retrieved on January 17, 2007 from http://gmazzocato.altervista.org/colorwheel/wheel.php

McCathieNevile, C., and Koivunen, M. (2000). Accessibility Features of SVG. *W3C.* Retrieved September 1, 2006 from http://www.w3.org/TR/2000/NOTE-SVG-access-20000807/

Milne, S. (2005). Are guidelines enough? An introduction to designing Web sites accessible to older people. *IBM Systems Journal,* 44(3), 557 – 571.

Neilsen, J. (1994). Heuristic Evaluation. In J. Neilsen & R. L. Mack (Eds.), *Usability Inspection Methods*, John Wiley & Sons Inc: New York.

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science,* 5(1), 14 – 37.

O'Grady, L., and Harrison, L. (2003). Web accessibility validation and repair: which tool and why?. *Library Hi Tech,* 21(4), 463 – 470.

Paddison, C., and Englefield, P. (2004). Applying heuristics to accessibility inspections. *Interacting with Computers,*16, 507 – 521.

Paternò, F. (2000). *Model-Based Design and Evaluation of Interactive Applications.* Great Britain: Springer. Retrieved on May 5, 2007 from http://books.google.com/books?id=zCyXcL3YcjwC&printsec=frontcover#PPP1,M1

Petrie, H., Morley, S., McNally, P., O'Neil, A., and Majoe, D. (1997). Initial Design and Evaluation of an Interface to Hypermedia Systems for Blind Users. *Proceedings of the 8th ACM Conference on Hypertext*, 48 – 56. Retrieved on May 10, 2007 from [Login required] http://doi.acm.org/10.1145/267437.267443

Richards, J. T., and Hanson, V. L. (2004). Web Accessibility: A Broader View. *Proceedings of the 13th international conference on World Wide Web,* 72 – 79. Retrieved on February 15, 2007 from [Login required] http://doi.acm.org /10.1145/988672.988683

Schimiguel, J., Melo, A. M., Baranauskas, M. C. C., and Medeiros, C. B. (2005). Accessibility as a quality requirement: geographic information systems on the web. *Proceedings of the 2005 Latin American conference on Human-computer interaction*, 8 – 19. Retrieved on September 17, 2007 from [Login required] http://doi.acm.org /10.1145/1111360.1111362

Slatin, J., and Rush, S. (2003). *Maximum accessibility: Making your web sites more usable for everyone*. Boston: Addison-Wesley.

Tanaka, E. H., Bim, S. A., and Rocha, H. V. (2005). Comparing Accessibility Evaluation and Usability Evaluation in HagaQue. *Proceedings of the 2005 Latin American conference on Human-computer interaction,* 139 – 147. Retrieved on February 14, 2007 from [Login required] http://doi.acm.org /10.1145/1111360.1111374

Teuber, C., and Forbig, P. (2004). Different Types of Patterns for Online-Booking Systems. *Proceedings of the 3rd annual conference on Task models and diagrams*, 91 – 97. Retrieved on May 1, 2007 from [Login required] http://doi.acm.org/10.1145/1045446.1045464

Tonn-Eichstadt, H. (2006). Measuring Website Usability for Visually Impaired People – A Modified GOMS Analysis. *Proceedings of the 8th international ACM SIGACCESS conference on Computers and accessibility,* 55 – 62. Retrieved on February 16, 2007 from [Login required] http://doi.acm.org/10.1145/1168987.1168998

Thatcher, J. (2002). *Constructing accessible web sites*. Birmingham, U.K.:Glasshaus.

Thatcher, J., Burks, M. R., Heilmann, C., Henry, S. L., Kirkpatrick, A.,Lauke, P. H., Lawson, B., Regan, B., Rutter, R., Urban, M., and Waddell, C. D. (2006). *Web Accessibility: Web Standards and Regulatory Compliance.* New York: Springer-Verlag.

Treviranus, J., McCathieNevile, C., Jacobs, I., & Richards, J. (Eds.). (2000). Authoring Tool Accessibility Guidelies 1.0. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/TR/ATAG10/

Treviranus, J., Richards, J., & May, M. (Eds.). (2006). Authoring Tool Accessibility Guidelines 2.0. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/TR/ATAG20/

University of Toronto Libraries [UTL]. Request Articles or Books from other Libraries – Students, Faculty, Staff. Retrieved on February 28, 2007 from http://content.library.utoronto.ca/services/ill/students.html

US Department of Health and Human Services. (2006). Research-Based Web Design & Usability guidelines. Retrieved on September 15, 2007 from http://usability.gov/pdfs/guidelines.html

Vanderheiden, G., and Chisholm, W. (2002). Requirements for WCAG 2.0. *WAI.* Retrieved on September 1, 2006 from http://www.w3.org/TR/2002/WD-wcag2-req-20020426/

Vilen, Jaakko (2006). Accessibility *in Internet Services – Case Electronic Banking*. Masters Thesis. Helsinki University of Technology, Finland. Retrieved on November 17, 2007 from [Login required] http://simplelink.library.utoronto.ca/url.cfm/1483

Wallis, J. (2005). The web, accessibility, and inclusion: networked democracy in the United Kingdom. *Library Review*, 54(8), 479 – 485.

W3C. (2006a). Web Accessibility Initiative. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/WAI/.

W3C. (2006b). Authoring Tool Accessibility Guideline Overview. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/WAI/intro/atag.php

W3C. (2006c). User Agent Accessibility Guidelines. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/WAI/intro/uaag.php

W3C. (2006d). Essential Components of Web Accessibility. *W3C.* Retrieved on January 15, 2007 from http://www.w3.org/WAI/intro/components.php

W3C. (2007). Education and Outreach Working Group (EOWG). *W3C.* Retrieved on May 10, 2007 from http://www.w3.org/WAI/EO/

WebAim. (n.d.). The Web Accessibility Initiative (WAI): Web Content Accessibility Guidelines 2.0 (WCAG 2.0). Retrieved October 18, 2007 from http://www.webaim.org/standards/wai/wcag2.php

Web Content Accessibility Guidelines Working Group [WCAG WG]. (2007). WCAG 2.0 Quick Reference: A Customizable List of WCAG 2.0 Requirements (Success Criteria) and Techniques. Retrieved on November 21, 2007 from http://www.w3.org/WAI/WCAG20/quickref/

Appendices

Appendix A: Other web accessibility guidelines

IBM accessibility

The IBM heuristics are based on two views of the web site (Paddison & Englefield, 2004). , which are the technical accessibility, and the view of usable accessibility. Technical accessibility (Paddison & Englefield, 2004) refers to the technical components of the web site, such as incorporating the debounce time setting (Hanson et. al., 2005) into the input time out for a web based form. The term usable accessibility (Paddison & Englefield, 2004) refers to the usability issues with the use of a web site, such as consistency in ways to navigate in a web site. Some of the heuristics in this evaluation technique (Paddison & Englefield, 2004) include providing meaningful and relevant alternatives to non-text elements, having consistent navigation, allowing keyboard-only users to be able to use the web site along with other groups, not having to rely only on text color to distinguish items, and making sure that the web site is compatible with assistive technologies.

Section 508

The US Federal government has introduced Section 508 as an initiative (Hackett, Parmanto, & Zeng, 2005) in making all the Federal government web sites accessible. This guideline is among the most prevalent guidelines used in North America (Lazar et. al., 2004; Milne, et. al., 2005). The US federal government has amended the Rehabilitation Act Amendments in 1998 with Section 508 (Hackett, Parmanto, & Zeng, 2005).

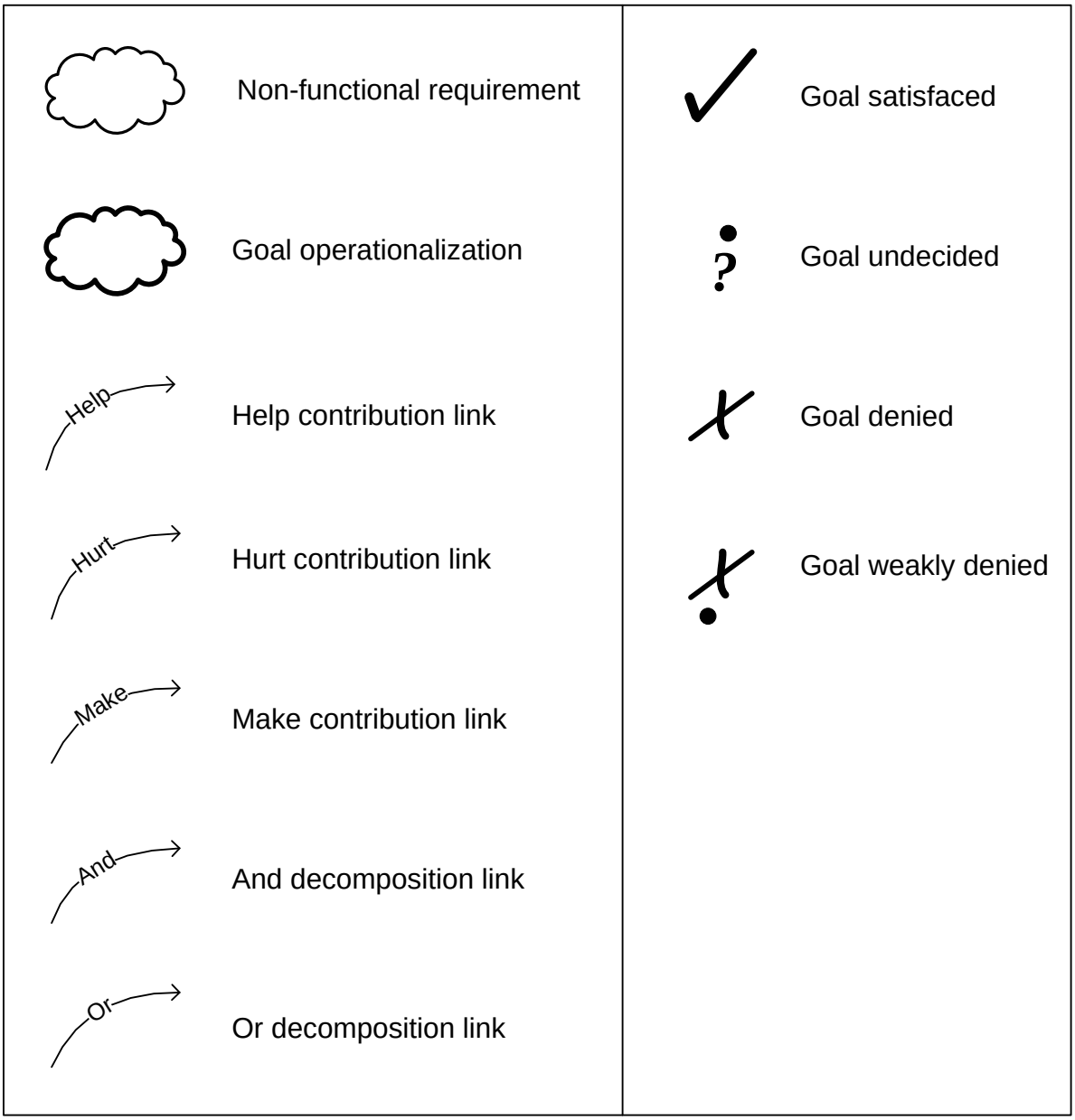
Research-Based Web Design & Usability Guidelines

This set of guidelines (US Department of Health and Human Services, 2006) comprises of guidelines related to accessibility and usability of web sites. Each guideline is given a relative importance rating, and a strength of evidence rating. Relative importance rating is the rating provided by the original guidelines where this guideline has been derived from. Strength of evidence rating is provided based on research findings. Read the book by US Department of Health and Human Services (2006) for more information.

Appendix B: Notations

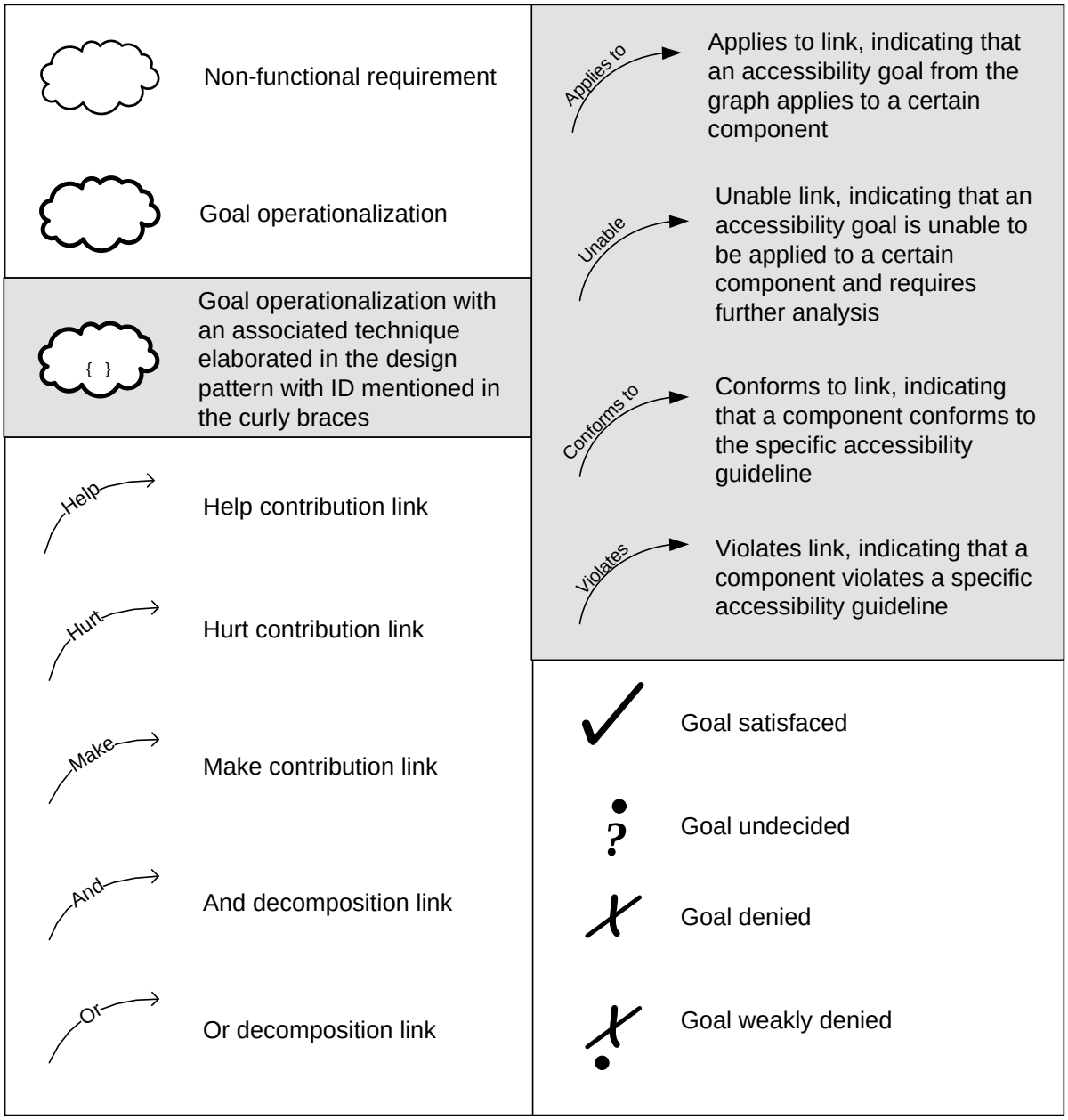
Part I: Notations for the conventional Goal Oriented Modeling

Following are the notations that have been used in this research in relation to the conventional goal oriented modeling technique.



Part II: Notations for the proposed technique

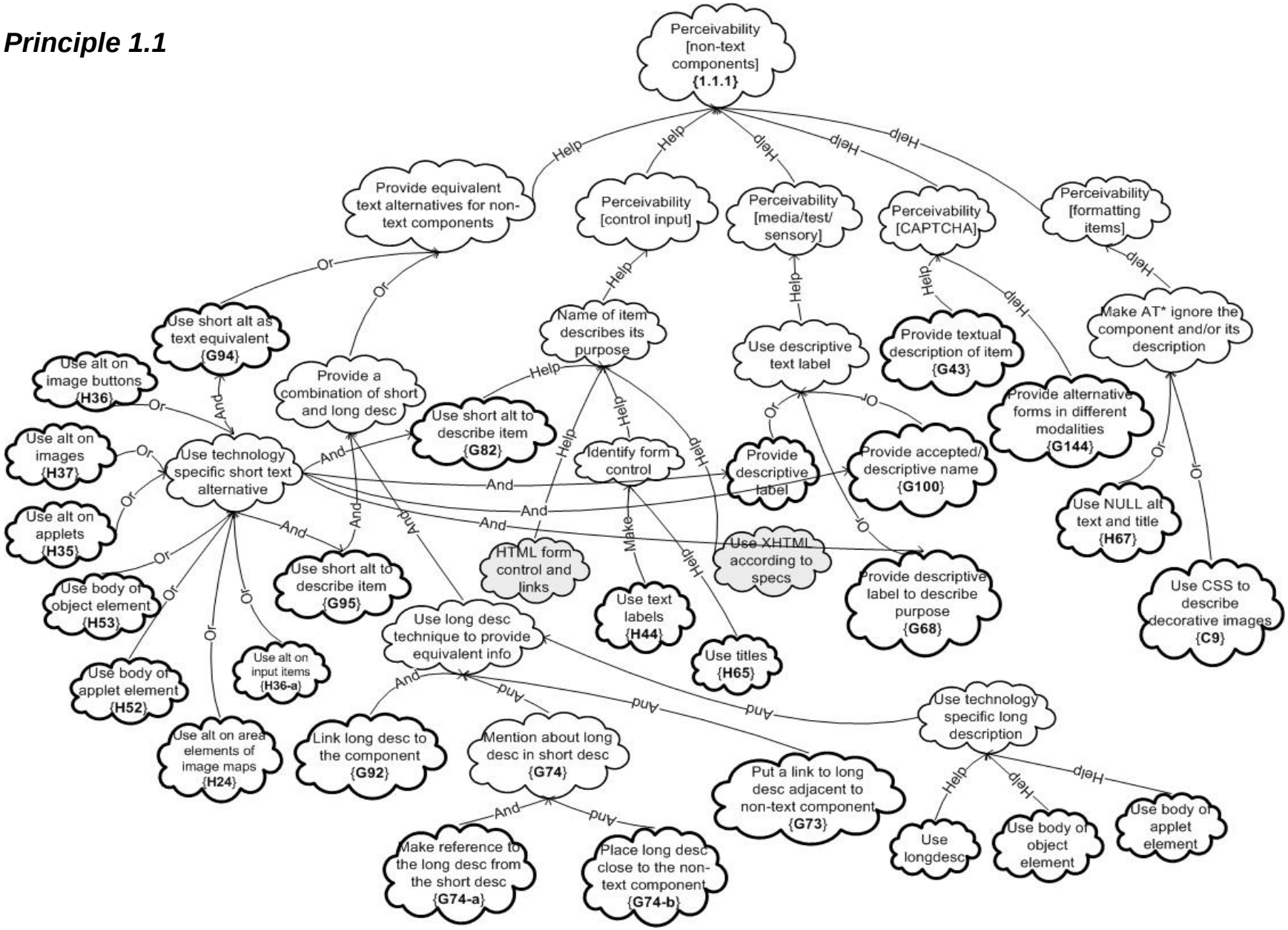
Following are the notations that have been used in the proposed technique. Note that this combines the conventional goal oriented modeling notations and the additional notations introduced in this research (in the shaded area).



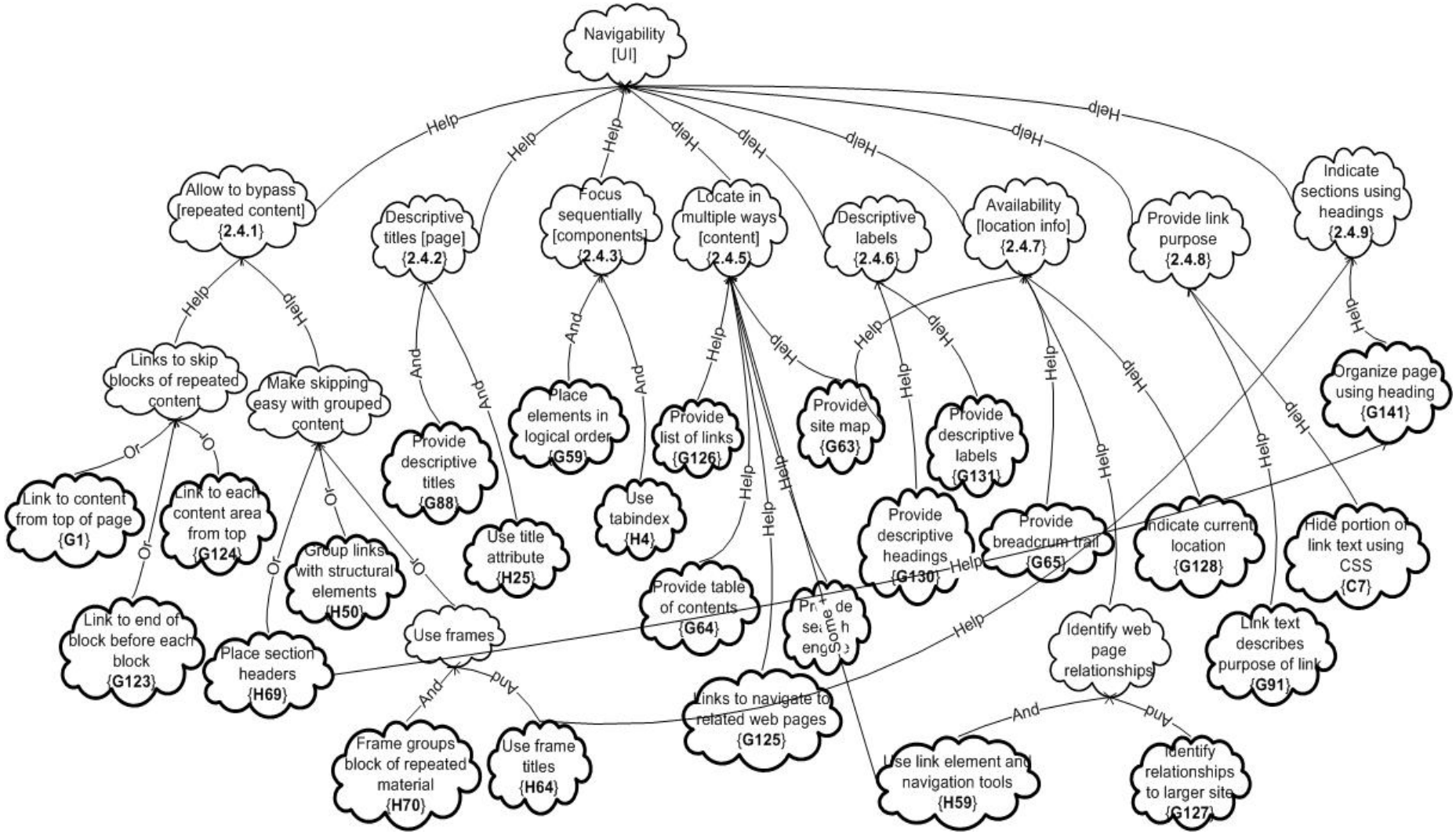
Appendix C: The reorganized guidelines

Following are the three goal graphs for three guidelines that have been developed in this research. Please refer to chapter VI for Information on creating these goal graphs

Principle 1.1



Principle 2.4



Principle 3.1