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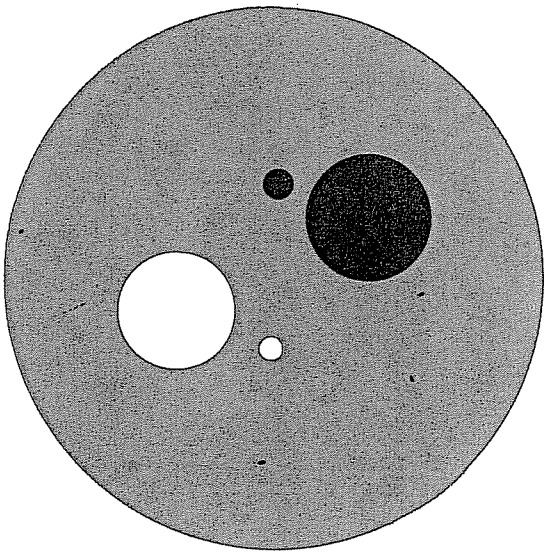

REPRESENTING TEXT STRUCTURE FOR AUTOMATIC PROCESSING

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Computer Sciences Technical Report #324

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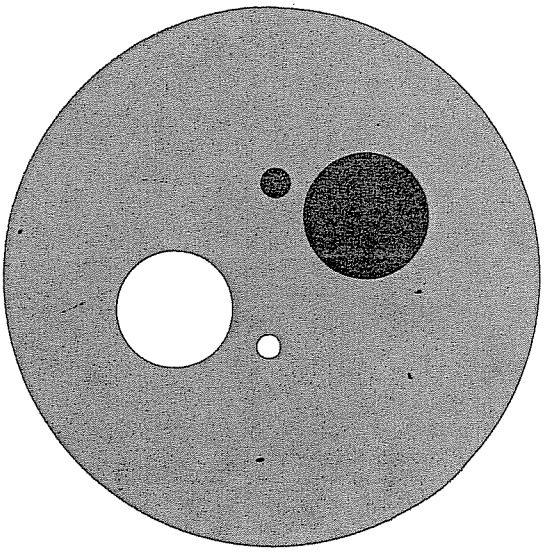

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Representing Text Structure for Automatic Processing

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A thesis submitted in partial fulfillment of the requirements for the degree of

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1978

Representing Text Structure for Automatic Processing

Lynne Ann Price

Under the Supervision of

Professor Larry E. Travis

Text structure refers to the semantic and syntactic relations in a continuous, linear sample of written language. Because there is more to a text such as a novel or reference manual than the ideas embodied within it, consideration of structural features increases the possibilities for text processing by computer. For example, question-answering systems can use structural information to locate passages likely to contain requested data. Also, automatic text generators must account for the order in which material is presented and the amount of detail provided.

This thesis proposes a multi-purpose notation for representing text structure, called the strep. While the strep can be used to encode the results of previous structural studies on restricted classes of texts, it is more flexible and complete than earlier notations. In fact, the volume of the encoded data suggests that the strep be manipulated by computer.

Two classes of structural relations are emphasized. The first group, which parallels other studies, describes the hierarchy formed by the chapters, sections, and paragraphs of a text and identifies the function served by each passage. The second type of relationship involves recurring concepts (e.g., statements in a programming language or themes, locations, characters in a story) that appear throughout a text. The strep allows the analyst to indicate interactions among such concepts and to associate them with pertinent portions of a text.

Although no algorithm is suggested for automatic generation of a strep from an input text, the usefulness of the notation is demonstrated by its applications based on manual encoding. In particular, a system for interactive use of programming documentation is designed. This program allows users to locate material without alternating between an index and the body of a manual. As each passage is displayed, cross-referenced sections and other related information can easily be obtained.

Acknowledgements

I would like to thank everyone who assisted this research. Both my advisors, Dick Venezky and Larry Travis, were very helpful. I appreciate Dick's continued support after he left Madison. I am also grateful to the other committee members, Greg Oden for his frequent encouragement, Raphael Finkel for his help with the writing, and Manindra Verma for his time and willingness to rearrange his schedule.

Several of my friends, especially Nathan Relles, spent many hours discussing my ideas and suggesting revisions to the text. Sally Handy-Zarnstorff, Paul Lustgarten, Nancy Zompolas, and Greg Scragg also contributed. Art Rasmussen drew the figures.

Finally, a brief note to my husband: the kids and I will be reacquainted next year when its your turn to spend every evening at school.

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1. General Description

1.1 Introduction

Computer processing of natural language has many facets.[1] Research in input and output of language includes optical scanning, speech recognition, and speech synthesis. Computers are used for lexical analyses of the distribution and frequency of words. Knowledge representations, most notably semantic networks, organize the information expressed in texts as well as the background knowledge needed to interpret them. Linguistic tools such as transformational grammar, case grammar, and augmented transition networks allow parsing and generation of single sentences. Within small groups of sentences, problems that have been investigated include presupposition, inference, implication, and anaphora. The state of the art is

1. Research by Schank, Charniak, Wilks, Woods, Winograd, Quillian, Raphael, Salton, Strasbourger and many others [5, 6, 7, 11, 14, 22, 23, 47, 57, 58, 62, 67, 70, 72, 77] is pertinent to the ideas discussed in this paragraph.

reflected by programs that answer questions, paraphrase, and generate simple stories.

Nevertheless, many unsolved problems still prevent a successful Turing test on the use of long written texts such as novels or textbooks. To process these texts in a human-like fashion, an understanding of their overall organization is needed. The term text structure refers to the semantic and syntactic relations within a sample of natural language. The goal of the work presented in this dissertation is to formulate and test a method for representing the global structure of written texts with the properties of continuity and linearity described in Chapter 2. Three questions are investigated in the following chapters:

1) What is text structure?
2) How can text structure be represented?
3) What are some practical applications of a notation for representing text structure?

It is difficult to enumerate the properties that constitute text structure. Certainly, the order in which ideas are presented is an obvious and important component of structure. Semantic relationships other than order exist among the sections of a text and must be represented in a structural description. Nonadjacent segments are often semantically connected. An entity (e.g., a character in a story or a statement in a programming language) may be

mentioned at various points in a text. Similarly, different aspects of a single topic (e.g., parent-child relationships or program efficiency) may be considered at different times. These and other associations must be included in a definition of text structure. Once text structure is adequately defined and a corresponding notation established, numerous tasks can be automated.

Structural representations could be used by fact retrieval and question answering systems to locate a passage likely to contain needed data. Instead of formulating a concise answer to a user's question, an interactive system could display appropriate portions of a document so that the user could extract the needed information himself.

Automatic text generation could be based on descriptions of text structure that are supplied by a user or are themselves computer-generated. Rather than composing long passages of polished natural language, programs could be used to produce outlines or other structural descriptions of needed texts. Actual wording could then be supplied later by the user.

Text structure could also be used to evaluate the readability of a text. Characteristics of paragraph structure have already been used in experiments dealing with reading time and retention of ideas [35, 36, 37]. For

purposes such as assigning grade levels to children's books, assessment of readability is currently based on easily quantifiable features such as vocabulary size, number of syllables per word, and number of words per sentence [21, 44]. A structural representation could be used to add an organizational term to existing formulas.

In an interactive environment, structure could underlie a set of tools for partially automating text revision. For example, a program could perform various transformations on an input text to increase its readability without altering its content. Possible transformations include rearrangement of material and addition of examples.

Structural information can also be used in the comparison of related texts. Instead of evaluating a single structural representation, a program could be designed to select the best from a group of outlines or to synthesize a new structural description containing the most desirable features of each input text. Examination of similar texts need not be motivated by the desire to produce a revision. Folklorists, for example, frequently make structural comparisons of different versions of a myth. Automation of some of their procedures would allow in-depth comparison of large classes of folktales.

The notation proposed below includes generalizations of the conventional table of contents and index. Use of the computer allows the encoding of more interconnections and details than would be possible with pen and paper alone. Complete automation of the process of generating structural representations is a difficult problem. However, many automatic tasks are feasible if such textual descriptions are manually supplied. As a partial test of the success of the introduced notation, its relevance to problems such as locating material in a text, revising texts, and computer-assisted writing is mentioned below. One application in particular, a system for interactive perusal of computer manuals, is discussed in detail. Although most attention is given to applications within computer science, the techniques discussed are applicable to linguistics, psychology, and the study of literature.

1.2 The Structure of This Text

This section sketches the organization of the remainder of this paper. Chapter 2 surveys structural features of texts. In Chapter 3, previous representations of text

structure are discussed. Chapter 4 presents a new notation, called the strep. To illustrate the applicability of streps to entire texts as well as isolated paragraphs, two complete examples are discussed in Chapter 5. These texts and their streps are included as Appendices A and B. To emphasize the generality of the strep notation, different types of texts are chosen. The examples in Chapter 5 are a Russian folktale and a science book for young readers.

Chapter 6 investigates the structural characteristics common to programming manuals. Two additional complete examples, a user's manual and internal documentation for a large program, are discussed. The streps for these examples form Appendices C and D. Chapter 7 uses the characteristics identified in Chapter 6 to design an on-line documentation system based on streps. The last chapter, Chapter 8, mentions other applications of the strep notation. Finally, a glossary summarizes the expressions defined in this thesis as well as some of the linguistic and computer science terms it uses.

2. Defining Text Structure

2.1 Introduction

A natural sense of text structure enables a reader to recognize the protagonist in the opening pages of a novel. The same knowledge influences his feeling that the story does (or does not) have a satisfactory conclusion. He can recognize sequences of sentences that do not form coherent texts. This ability is documented by recall experiments, such as those of Stein [68, 69], where subjects transform ill-formed narratives into texts with conventional structure.

Text structure is pertinent to any field of research dealing with natural language: the linguist enumerates ways in which words can be combined, the sociologist identifies characteristics of different groups of speakers, the anthropologist compares related cultures by contrasting their mythology, the critic evaluates a particular work of literature, and the folklorist categorizes elements that occur in fairy tales. Although the structure of the studied

texts is important to all these tasks, investigation of structure takes various forms under the assorted disciplines. Even within a single field, terminology may vary. Friedman [28], for example, lists seven uses of the word "structure" in the context of literary criticism. Some of the computer applications suggested in Chapter 1 use different aspects of text structure than do others. Because of this variety, it is important to identify the structural features of natural language texts before a notation for describing the structure is introduced.

2.2 Texts to be Considered

This thesis is primarily concerned with written prose that is complete, continuous, and linear. Complete texts include short stories, novels, newspaper or magazine articles, and essays but exclude isolated paragraphs. Continuous texts consist of coherent grammatical sequences; they exclude sequences of natural language expressions that are never read consecutively nor combine to form larger language units. While timetables, telephone books, and dictionaries are composed of natural language elements, they are lists of language samples and not coherent texts

themselves. However, reference manuals, which may be used without being read in entirety, are not eliminated by the criterion of consecutive reading.

The constraint of linearity prevents consideration of nonlinear segments (e.g., figures, tables, and footnotes) in isolation. It does not eliminate linear texts containing these forms. For example, the structure of a tax table is that of a two-dimensional array in which most entries have both a row successor and a column successor. Because continuous natural language is linear, the tax table itself is not considered a text here. Nevertheless, the structure of a book on income tax preparation, which might contain such a table, is certainly a possible subject for this study. Simple transformations can be used to convert some texts to a strict linear form. Footnotes, for instance, can be parenthetically embedded at the points where they are referenced.

Despite these restrictions on the texts to be considered, the conclusions made in this research can be extended to other samples of language, including spoken conversation. A notation for text structure is valuable even if it does not completely describe the organization of every text, just as phonemic analysis, though useful, does not provide a complete description of the phonology of a

language; and just as context-free grammars, without generating an entire natural language, can provide insight into the syntax of large numbers of acceptable sentences.

2.3 Text Structure

A popular dictionary[1] defines structure as "the interrelationship of parts or the principle of organization in a complex entity." The parts of a text include its words, phrases, sentences, paragraphs and sections, as well as the ideas they present. Many types of relationships exist among these entities. Relationships of sound (e.g., meter, alliteration) and relationships of presentation (e.g., size and style of type, position on a page) are not relevant to the current study.

Another category that is not important here is formed by relationships pertaining to the wording and syntax used within a text. Several types of paraphrasing have little effect on meaning. These transformations include switching between active and passive forms of a sentence, substitution of an explicit statement for an implication, and the

1. The American Heritage Dictionary of the English Language (1969).

division of a lengthy sentence into two or more simpler ones. Such alterations subtly change the sense of a passage. However, experiments such as those by Bransford and Franks [8, 25, 26] suggest that the effect of these changes is so insignificant that readers are unlikely to remember the particular variation used in a passage. Furthermore, the meaning of these differences is outweighed by the contributions of other portions of the text. The substitution of a synonym for a single word in a novel, for instance, is likely to have only a minimal effect on the entire work. The structural features considered below pertain to the underlying ideas in a text, unencumbered by idiosyncracies of lexical choice and sentence structure. The following pages concentrate on relationships among larger units, sections containing several paragraphs, rather than smaller units such as single sentences. In particular, succeeding chapters emphasize the natural subdivisions of a text (e.g., chapters, sections) and the recurring elements common to non-adjacent passages (e.g., a location where different events occur, a subroutine whose use is mentioned in different contexts). Structural relationships may be very abstract (e.g., pertaining to a theme) or fairly concrete (e.g., dealing with the order in which facts are presented). The notation proposed in Chapter 4 allows an

analyst to encode the particular relationships that are relevant for his specific application.

The remainder of this chapter enumerates properties that may be included. In order to allow the flexibility required by different applications, no exhaustive list of structural relationships is given. Some aspects of structure cannot be discussed independently of the content of the text or the style in which it is written. Features considered here include chronological and textual orders of described events, point of view, relative emphasis of different sections, cause and effect relationships among the expressed ideas, and identification of cohesive elements.

2.4 Some Structural Relationships

A set of facts may be presented in different orders and with varying emphasis. Meehan [45] introduces the concept of a metanovel, where the events of a story, retained in the memory of a computer, are displayed in differing order and detail as determined by a user's input. As an example, a newspaper account and a detective story based on the same events have much in common. Their structures, however, are quite different. Technical material may also be arranged in

many ways. For instance, while an introductory description of a programming language may begin with the simplest forms of statements and show more general forms only in later chapters, a reference manual is likely to group together all variations of each construct.

A major difference in each of these groups of texts is the order in which ideas are presented. Many fictional and nonfictional texts detail a sequence of events. A basic part of their structure is the chronological order of these occurrences and the relationship of this order to that in which the events are presented in the text. Identification of the two orders is complicated since boundaries between events are obscure and arbitrary. Also, one event may be mentioned several times within a text, perhaps from the viewpoint of different characters or with additional details included with each repetition.

There is more to structure than order. It is not difficult to imagine texts in which corresponding ideas are presented in the same order but are given different emphasis. Point of view is a structural relationship between the narrator and a text. The importance of a textual element is dependent on the viewpoint of the narrator. Interpretation of an event varies among the participants. This idea is presented in more detail by

Abelson [2]. He discusses the effect of point of view on a reader's interpretation of a text, along with the implications of this interaction for automatic text processing. It makes little difference whether some stories are told in the first or the third person. However, this relationship should be noted in analyses of novels where portions are narrated by different characters (e.g., The Sound and The Fury).

Another form of emphasis is the elaboration of an idea. A description of a pair of experiments may briefly present the first set of results as preliminary work before completely detailing the second. Another report of the same work may thoroughly discuss the earlier experiment and refer to the second one as a confirming follow-up study.

The amount of elaboration may not be pertinent for some studies. Structure can be explored at several levels of detail. Variations of a mathematics textbook, for example, may use different numbers of sample problems to illustrate proven theorems. The number of problems certainly is a structural feature. For some applications, however, it is sufficient to indicate the presentation of a theorem followed by a block of worked exercises, and to ignore the actual number of problems within the block.

Meehan [45] makes a similar point using different terminology. He discusses levels of abstraction that can be used to describe stories. A single text, for instance, can be interpreted as a story about climbing a particular mountain, about mountain climbing, about adventure, about man conquering nature, about man in conflict with nature, or simply about conflict. Although Meehan does not explicitly discuss structure, any structural representation would be influenced by the level of abstraction considered.

Another structural relation is shown in the following segments used by Kintsch [35, 36, 37] in experiments on human text processing:

> A carelessly discarded burning cigarette started a fire. The fire destroyed many acres of virgin forest.

and

> A burning cigarette was carelessly discarded. The fire destroyed many acres of virgin forest.

The first paragraph explicitly states the cause of the fire, while the second only suggests it. The structural relationships between the component sentences are different in the two paragraphs. However, because the passages could serve the same function within a larger text, the difference

is not important at a less detailed level. Similar comments apply to another paragraph:

> Knowing his action would result in the destruction of many acres of virgin forest, the villain carelessly discarded a burning cigarette.

In this variation, the existence of the fire is never explicitly confirmed. Nevertheless, barring contradictory evidence elsewhere in the text, most readers would assume the fire did take place.

The relationships of implication and cause-and-effect that exist among the ideas conveyed by these paragraphs also occur among larger textual units. For instance, several chapters may create a collective impression of the state of mind of a novel's main character.

Several pairs of texts mentioned above have similar content but different structure. The reverse situation is also possible; texts dealing with different subjects often have parallel structures. Pike and Pike [51] give three stories with similar structure but very different content: one is from the New Testament, another is about a boy selling a dog, and the third predicts the experience of Martians arriving in Moscow in the future. All three stories consist largely of dialogue. The number of

exchanges is the same for all of the texts and rhetorical questions are used similarly. Consequently, some structural relationships among corresponding sentences are the same in all three texts. Similarly, programming textbooks present sample programs that solve the same problems regardless of the language being taught. At a more abstract level, expressions such as "topic sentence followed by three supporting statements" may be said to describe a structural relationship within any number of semantically unrelated paragraphs.

Many semantic connections can exist between nonadjacent passages. Events taking place during a single time period, references to a particular character, and occurrences with a common location are all possible groupings. More abstract themes may also be identified.

Harris and McDougall [33] state that an essay should be divided into mutually exclusive sections. Yet they leave it understood that in a coherent text some ideas must overlap these sections. The structure of a children's book, Millicent E. Selsam's When An Animal Grows [66], demonstrates this conflict. The author illustrates the different rates at which various species mature by describing both a baby gorilla and a lamb shortly after birth and then at selected stages of their growth. The

discussion alternates between the gorilla and the lamb in a very effective manner. The various sections of this text are not "mutually exclusive". Some sections are linked by the animal mentioned within them; others by the state of maturity described.

The recurrence of similar semantic entities throughout the flow of a discourse is called "cohesion" by Halliday and Hasan [32]. While cohesion is an essential factor in differentiating between texts and sequences of unrelated sentences, the features that indicate cohesion among textual elements are applicable in non-linguistic contexts as well. Many of the connections among segments of continuous discourse are also appropriate to other means of organizing information. The same types of semantic relationships that occur in samples of natural language exist among entries in timetables, encyclopedias, computerized data bases, and even entire libraries. Any categorization of semantic elements in discourse might be extendable to these other media as well. Grimes [31] describes the range of material facing linguists who consider discourse rather than single sentences:

> ... beyond the ordered paradigms and mildly controversial counterexamples of sentence grammar they see business letters, conversations, restaurant menus, novels, laws, nonverbal behavior, movie scripts, editorials, without end.

The inclusion of "nonverbal behavior" in this list illustrates that discourse shares properties with other human actions. The problem of identifying the relations among the elements in a sequence of language acts is a special case of the more general goal of understanding human behavior.

3. Representing Text Structure

3.1 Introduction

A new representation of text structure should preserve and expand previous uses. At the same time no researcher should be forced to encode relationships in which he is uninterested. The approach developed in Chapter 4 allows various structural repesentations to be made for a single text. Of the various structural features identified in Chapter 2, the analyst who encodes a particular representation may select those that are relevant for a specific application. The different representations for one text vary in the amount of detail contained, the type of feature emphasized, and the relationships specified between nonadjacent passages. This chapter focuses on methods for representing text structure. Examples of notation and terminology used to describe textual organization are preceded by a discussion of some of the goals of this research. Features common to several previous studies are interpreted with respect to the stated criteria.

Every notation is dependent on units of some sort. As described in more detail below, structural units used in previous research include the function (e.g., introduction, act of villainy) and the motif (e.g., animal tale). Functions classify the purpose served by a portion of a text; motifs categorize the plot of a story. Discussing the choice of units for the structural study of folkore, Dundes [18] points out that units are used to compare elements from different folktales as well as to refer to pieces of individual texts. The possible applications of a general-purpose notation are partially determined by the units used.

The notation introduced below is intended to encode the relationships described in the previous chapter. The following criteria can be used to measure its success:

practicality: The resulting description should be economically usable in several practical applications.

generality: The notation should not depend on texts written in expectation of analysis by the proposed method. It should be applicable to different classes of texts. It should not be restricted to a particular language, i.e., to English.

order: The order in which ideas are presented should be representable.

function: The functions served by each portion of the text should be identified.

cross-reference: The semantic entities (e.g., themes, locations, times, characters) that recur throughout a text should be indicated and associated with appropriate parts of the discourse.

flexibility: The notation should allow different descriptions of a single text, emphasizing different features and providing different details.

completeness: The notation should be applicable to entire texts. It should be able to represent all needed structural relationships. However, there should be no requirement to include unneeded information, even if it could be relevant for other structural analyses.

incrementality: The method should be applicable to texts (e.g., programming manuals) that are subject to revision. It should be possible to obtain a structural description of a revised text from descriptions of the previous version and of the modifications.

3.2 The Hierarchic Approach

There is no obvious method for encoding text structure. Outlines and tables of contents are common partial representations, but they are simplifications that do not satisfy the criteria of function, cross-reference and completeness. Another familiar approach, which encodes function alone, is the traditional plot diagram indicating

developing incidents, the culminating incident, resolution of suspense, climax, and the conclusion of a story.

Propp's characterization of Russian fairy tales is one of the better-known attempts to classify a restricted group of texts. Propp defines thirty-one functions, such as trickery, villainy, and magical agent that occur in these stories. Not all of the functions occur in every tale, but the functions that appear follow a particular order. There are multi-move tales in which one story is embedded within another. For example, before providing his magical assistance, a helper may require the hero to perform some task. As the hero achieves this subgoal, the story steps through a new sequence of functions embedded in the main tale. Only a few functions permit another move; i.e., embedding may occur only at certain points in a story.

Propp also defines subclasses of his functions. For example, absentation, in which a member of the hero's family leaves home, may take the form of the departure of a member of the older generation (e.g., when parents leave for work), the death of the parents, or an expedition of the children (e.g., they go to gather berries). He uses a linear representation for the structure of a tale. An example is

$$\beta^3 \delta^\alpha A^1 B^1 C \uparrow H^1 - I^1 K^4 \downarrow W^0$$

where the letters and arrows represent functions and the superscripts indicate subclasses of functions. Should embedding occur, the different moves are distinguished by subscript. This notation is equivalent to a tree in which siblings represent the functions of one move and the descendants of a node correspond to an embedded tale.

Almost without exception, Russian folktales seem to fit this mold. Not only do events occur in the prescribed order, but virtually every element of a story fulfills one of these functions. There are complications, of course: a single event may serve two or more functions. Also, without attempting to represent the roles played by various characters, Propp discusses seven possible spheres of action: those of the villain, the donor, the helper, the princess and her father, the dispatcher, the hero, and the false hero. He points out that a character may participate in more than one of these spheres. Thus, a particular maiden who presents the hero with a magic ring is both a donor and a princess. Similarly, several characters may act in a single sphere. For example, after a dragon is killed, any of his female relatives may assume the role of villain. An example given in Chapter 5 extends Propp's analysis of one tale to include this type of detail.

Propp's work has stimulated further research, including at least two computerized story-generators [19, 39, 40]. Both folklorists who are favorable toward Propp's analysis [20] and those who are critical of his work [9] have had to modify his functions significantly before applying them to tales of other ethnic groups.

Although Propp's notation satisfies the criteria of order and function, it does not provide for cross-reference or completeness. Rumelhart [61] describes the structure of a broader class of texts. He gives a context-free grammar describing the syntax of stories with rules such as

Story -> Setting + Episode

and

Episode -> Event + Reaction

These syntactic rules are accompanied by semantic rules, for example:

ALLOW(Setting, Episode)

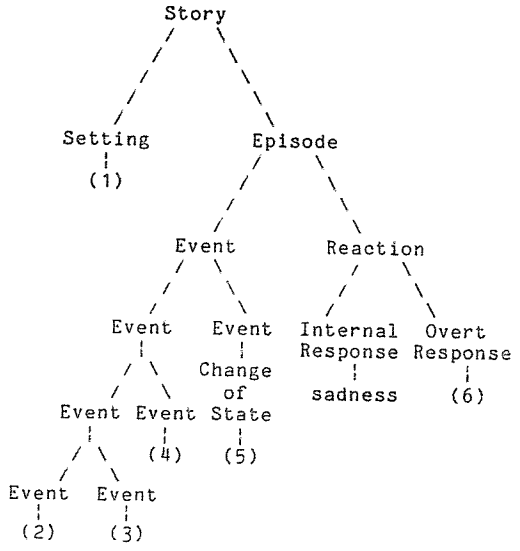
and

INITIATE(Event, Reaction)

The semantic rules are used to define conventions for paraphrasing. The structure of a story is represented by a pair of derivation trees, one corresponding to the syntactic rules, the other to the semantic rules. The two trees are essentially isomorphic. The relationship between a story

and its trees is indicated by labels attached to the leaves. The labels refer to either sentences from the story or to underlying elements that do not explicitly appear in the surface structure. The paragraph below is shown along with the syntactic tree that results when it is analyzed according to Rumelhart's grammar. The clauses have been numbered to identify the text portions assigned to each leaf in the tree. (This tree is a slight modification of the one shown by Rumelhart. The original cannot be derived using his grammar.)

(1) Margie was holding tightly to the string of her beautiful new balloon.
(2) Suddenly a gust of wind caught it.
(3) The wind carried it into a tree.
(4) The balloon hit a branch and (5) burst.
(6) Margie cried and cried.



The feeling of sadness that triggers Margie's crying is not overtly mentioned in the text.

Rumelhart does not claim that his grammar permits a unique analysis of a text. The content of nodes (3) through (5) may be said to consist of a single event, a pair of events (movement into the tree and breaking against the branch), or three distinct events (as Rumelhart has chosen). These alternatives reflect a difference in the level of detail included in the tree. Other variations reflect different categorizations of textual elements. The breaking

of the balloon, for example, may be considered an event as well as a change of state. Ambiguities of these types multiply quickly when longer texts are studied.

Rules such as Rumelhart's correlate highly with a reader's intuition about the nature of stories, especially when used with the very short narratives he analyzes. This representation scheme, although applicable to larger texts, is insufficient for describing their structures according to the criteria given above. As with Propp's notation, there is no provision for cross-reference. Furthermore, these rules, designed in conjunction with event-oriented texts, violate the criterion of generality. They require extensive modification and supplementation before they can be used with technical documents, such as computer reference manuals.

Rumelhart uses his grammar to define algorithms for paraphrasing simple stories. Stein [68, 69] merges Rumelhart's semantic and syntactic trees to investigate children's interpretations of ill-formed stories. She adds the connectives used in Rumelhart's semantic rules to the syntactic tree by attaching them as labels on the relationships between siblings. For example, she would merge the pair of subtrees shown in Figure 3.1 into the single construct shown in Figure 3.2

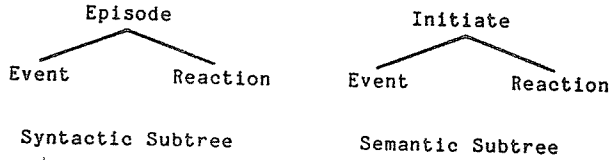


Figure 3.1 Rumelhart's Notation

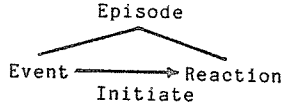


Figure 3.2 Stein's Notation

A feature common to many analyses of structure, including those of Propp and Rumelhart, is the division of a text into a sequence of nonoverlapping topics, each of which may in turn be subdivided. Other formulations based on a hierarchic approach include those of Kintsch, who studies reading time and retention [35, 36, 37]; Chafe [10], who investigates the processes used by storytellers when converting knowledge into words; and Pitken [52], who uses a hierarchic representation of text structure as a tool for teaching composition.

3.3 Non-Hierarchic Methods

There are representations of text structure that do not depend on a hierarchy of subdivisions. The abstract-like structure used by van Dijk [16] is an example. Petofi [50] suggests an elaborate matrix specifying the relationships between each pair of sentences in a discourse.

Kahn [34] describes the structure of a class of potential texts with a finite state automaton based on a pecking order among the races of the characters in The Faerie Queene. Members of a race higher in this order can never be defeated by members of a lower race. Any string accepted by the automaton represents a sequence of possible battles and their outcomes and hence provides an outline for a possible story. Unfortunately, this simple technique can not be generalized to significantly broader classes of texts.

3.4 Structurally Insignificant Variations of a Text

Chapter 2 argues that order of presentation is an important facet of text structure. It also claims that the substitution of an active sentence for a passive one does not affect structure. Since order of subject and object is a major difference between the active and passive forms in English, it must be assumed that the order of large discourse segments is structurally significant while that of smaller pieces is not. (This hypothesis presupposes a cutoff between large and small segments.)

Some studies focus on the question of varying order without changing structure. Labov and Waletzky [42] work with short narratives about personal experience in an attempt to identify speech patterns used by speakers from different groups. They analyze selected portions of spoken discourse, claiming each might fulfill a single function in a scheme like Propp's. They break each sample into clauses and calculate the "displacement set" of each. These sets are composed of the groups of neighboring clauses with which a particular clause can be exchanged without altering the meaning of the narrative. For example, in the segment,

and I crossed the street
and they was catchin' up to me
and I tripped, man

the order of the first two clauses may be reversed. However, if the first clause is moved to the end, the interpretation of the entire sequence is changed.

A general notation for text structure should be able to encode this relationship of interchangeability. It should also be able to ignore portions of a text that are unimportant for a particular application. Dorfman [17], for instance, removes "nonfunctional" incidents from French and Spanish epics. This removal allows him to reduce ten stories to three structural patterns. One of these patterns follows:

(1) The family quarrel.
(2) The insult.
(3) The act of treachery or of glory.
(4) The punishment or reward.

There are other applications where some portions of a text can be omitted. Transitory passages are not needed when fine details are irrelevant. Phrases linking one concept to the next do not clearly belong with either idea. Since their contribution to the broad organization of a text is small, such phrases may be given disproportionate stress by a representation that distinguishes them from the

surrounding text. Short summaries of a few immediately preceding ideas help to smooth the flow of a text for a reader, but do not really belong with any of the ideas or warrant a new section for themselves. Of course, a detailed analysis may be concerned precisely with the manner of transition between ideas. For this purpose, transitory passages should be identified and separately delimited.

3.5 A Hierarchic Composite

This chapter presented criteria for an adequate structural notation. Previous research has produced several hierarchic representations. A tree is a convenient formalism for representing ordered, nonoverlapping subdivisions of a linear string. Furthermore, each node in a structure tree can be labelled to indicate the functions filled by the text segment associated with it.

Such trees do not provide guidelines for subdividing a text; the Margie story demonstrates that there may be no unique way to do so. Furthermore, the relation between the structure tree and the body of the text is not straightforward. The simplest choice is to break the text into contiguous non-overlapping pieces. These passages can

be attached to the leaves so that the text can be reconstructed by a traveral of the frontier from left to right. Other types of association are possible, however. As mentioned above, it may be convenient to permute or omit some segments. The data attached to the nodes may be abstractions instead of actual text segments. Possibilities include propositions such as those of Kintsch [35, 36, 37], represented in words closely corresponding to those in the surface structure; concepts such as those expressed by Schank [47, 64] in terms of a few predetermined primitives; and ideas indicated by filling slots in a case system such as that defined by Frederikson [27].

This step towards a definition of structural units is in accord with several of the criteria listed above. Certainly the criteria of order, function, and flexibility are satisfied. The main discrepancy is that a structure tree aby itself does not cross-reference the entities that recur in a discourse. The present work provides an addition to other hierarchic analyses of discourse. In the following chapter, a means for supplementing a tree with cross-referencing is presented.

4. Streps

"If you don't find it in the Index, look very carefully through the entire catalogue."

Consumer's Guide, Sears, Roebuck and Co. (1897)
quoted by D. Knuth, The Art of Computer Programming, Vol. 3, p. 710

4.1 Introduction

This chapter presents the notion of structural representation or strep. A strep consists of a passage tree, a passage-dependent network, and an optional passage-independent network. Two classes of structural relations are emphasized. First, the passage tree represents the linear and hierarchic nature of texts discussed in the previous chapter and encodes the function of text segments. Second, the passage-dependent network identifies the interplay of concepts that recur throughout a text and associates pertinent portions of the text with each concept. For applications that require other structural information, the passage-independent network identifies

relationships among recurring concepts that pertain to the entire text rather than isolated passages and encodes structurally significant elements of content. The form of each component of a strep is elaborated below.

4.2 The Passage Tree

The hierarchy that represents the natural subdivisions of a text is called the passage tree; each node in the tree is called a passage. Leaves of the passage tree are connected to the text in some fashion; non-terminal passages incorporate the connections of their descendants.

One type of connection associates leaf passages with portions of the document so that the text can be reconstructed by a left-to-right traversal of the frontier. Nodes above the leaves then refer to the concatenation of the text segments represented by their descendants. The root of the passage tree corresponds to the entire text. When this connection is used, the word "passage" has its usual meaning of a contiguous section of text.

The exact appearance of a particular passage tree is affected by the application and the analyst's philosophy. To prepare a text for the on-line documentation system

proposed in Chapter 7, an expert isolates the shortest text segments that are complete enough to be understood out of context. Typically, though not necessarily, these segments consist of single complete paragraphs. They are often separated by segments that are not meaningful in isolation (e.g., "In the first case", "For example"). The minimal sections and intervening phrases are associated with leaves of the passage tree. Nodes above the leaves indicate related passages with a coherent theme: groups of minimal segments that might be displayed together.

Some hierarchic representations of text structure are not based on segmentation. Kintsch [35, 36, 37], for example, uses abstract propositions. In Rumelhart's analysis of the Margie story [61], most of the leaves do correspond to text sections. In addition, Margie's feeling of sadness is represented in the tree even though it is not explicitly stated. Because these connections between the passage tree and the text are permitted in the definition of a strep, streps can be used as an alternate notation for analyses that do not depend on a strict segmentation of the text. However, in the examples given throughout the remainder of this paper, the passage trees are formed over adjacent, non-overlapping text segments.

To identify portions of a text, one or more names may be assigned to the corresponding node in the passage tree. In addition, one or more functions served by the passage may be indicated. While names pertain to an individual text, functions recur throughout a class of texts. The term identifier means "either name or functional label". It is not necessary that every passage in a strep be identified. Names for nodes near the root often have the form of chapter and section headings. An example of a passage with both types of identifiers is the last chapter in Alice in Wonderland; this passage has the names, "Chapter XII" and "Alice's Evidence", and serves the function of "conclusion".

With the nodes appropriately identified, passage trees can be used to describe textual analyses such as those of Propp [56], Chafe [10], and Rumelhart [61]. The identifiers used in these schemes (e.g., "monetary reward", "trick", "episode") are functional labels rather than names; they all indicate general functions served by passages in many texts.

4.3 The Passage-Dependent Network

4.3.1 Concept Graphs

With functional labels, the passage tree satisfies the criteria of order and function defined in Chapter 3. To satisfy the criterion of cross-reference, the passage tree is augmented with a set of concepts. Each concept represents a recurring element of the text, such as a character, location, time period, or repeated theme. Concepts are similar to keywords, key phrases, and sets of synonymous key phrases [54, 59]. However, keywords are surface structure features, while concepts are elements of the underlying structure. Also, keywords (e.g., "she" or "the President") may refer to different concepts at different points in a text.

Each identified concept is explicitly linked to pertinent portions of the document. The entire set of concepts forms an augmented index. It may be desirable to form different groupings of the references to a particular concept. In a biography, for instance, references to the main character's personal life might be distinguished from references to professional achievements. The associations between a concept and the text are represented by an acyclic

directed graph called a concept graph. Because concept graphs are directed, they can be described with terminology usually reserved for trees: the node at the tail of an arc is called the ancestor of the node at its head; nodes with no descendants are called leaves; nodes with no ancestors are called roots.

Leaf nodes in a concept graph are associated with a set of references to passages in the passage tree. The referenced passages need not be leaves in the passage tree -- a concept linked to any passage is pertinent to the text segments associated with all the passage's descendants. The set of references associated with a non-leaf node in a concept graph is the union of the sets associated with the node's children. Unlike the children of a passage in the passage tree, the children of a node in a concept graph are not ordered.

A possible concept graph is illustrated below. The example shows the use of the idea "constant" in a hypothetical manual for an algebraic programming language. The relevant chapter has been divided into passages whose content is indicated in the following list:

a) there are different types of constants
b) definition of integer constants
c) definition of real constants
d) legal values of integer constants
e) permitted range of reals
f) examples of integer constants
g) examples of real constants
h) the use of constants (type unspecified) in arithmetic expressions
i) first example of a constant within an arithmetic expression
j) second example of the use of constants within arithmetic expressions

Figure 4.1 Leaves of a Hypothetical Passage Tree

Figure 4.2 shows a concept graph for "constant" based on this segmentation of the manual.

constant

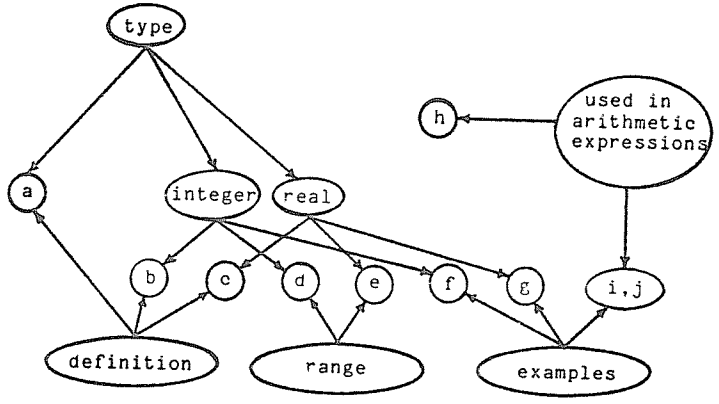


Figure 4.2 A Sample Concept Graph

Variations of this graph are possible. A trivial change is the addition of a node to the subgraph representing examples of constants within arithmetic expressions:

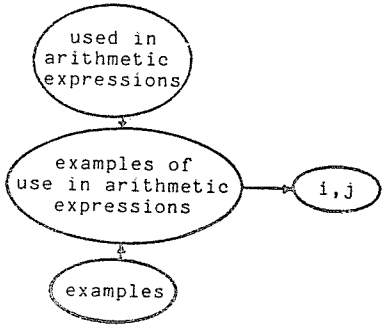


Figure 4.3 A Small Variation

More substantively, the second example might be longer and more complex than the first. The variations of the subgraph shown in Figures 4.4 and 4.5 preserve this information.

used in arithmetic expressions

examples of use in arithmetic expressions

examples

simple example — i

complex example — j

Figure 4.4
One Method of Distinguishing Simple and Complex Examples

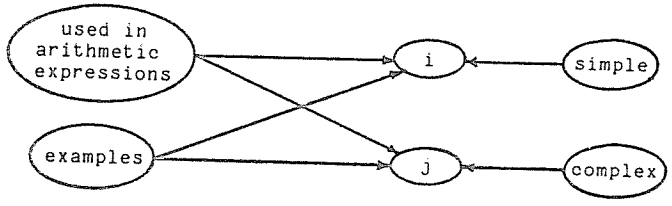


Figure 4.5
Another Method of Distinguishing Examples

Variations in the passage tree do not necessarily require dramatic changes to the concept graphs. The hypothetical manual could be segmented in less detail than was shown in Figure 4.1:

a') there are different types of constants
b') definition of integer constants
c') definition of real constants
d') legal values of constants
e') examples of constants
f') use of constants in arithmetic expressions
g') first example of constants within arithmetic expressions
h') second example of the use of constants in arithmetic expressions

Figure 4.6 A Less-Detailed Segmentation

The form of the concept graph in Figure 4.2 can be retained in a strep using the more abbreviated passage tree. In the condensed passage tree, no passage is restricted to the legal range of integer constants. However, a text segment

containing this information (passage d') can be located with the following graph:

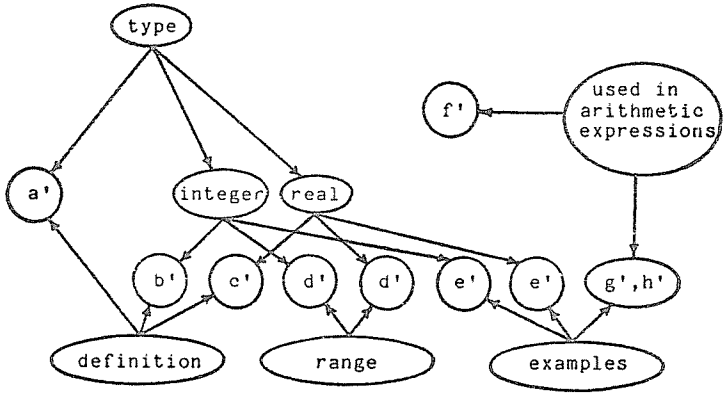


Figure 4.7 Multiple References to a Single Passage

This figure is almost identical to Figure 4.2. It illustrates a concept graph with several references to a single passage.

4.3.2 Category and Co-occurrence Nodes

A convenient notation exists for illustrating nonplanar graphs with figures that do not involve many crossing lines. Several copies of certain nodes are drawn and equated by identical labels. This convention is not followed in Figure 4.7, which has two distinct nodes referencing passage d' and two referencing e'. The misleading results of merging identically marked nodes can be seen in Figure 4.8.

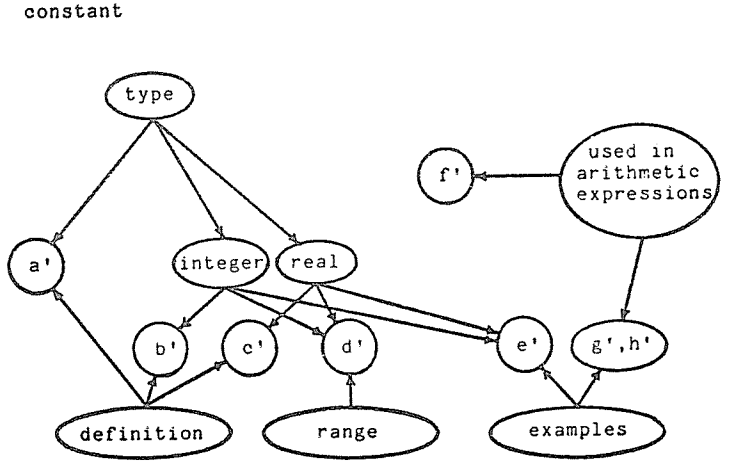


Figure 4.8 Erroneous Merging of Nodes

This condensation suggests that passage d' describes the range of constants that are at the same time both real and integer. The problem can be illustrated by imagining the operation of an interactive program for locating passages within a manual. Using the concept graph in Figure 4.7, a session might proceed as follows:

```
USER:     Tell me about integer constants.
PROGRAM:  Do you want to know about integer
          constants as they relate to
             1) "definition"
             2) "range"
          or 3) "examples"        ?
```

Figure 4.9
Possible Dialogue with an On-Line Documentation System

The program phrases its question by examining other ancestors of the descendants of "integer". Using this technique on Figure 4.8, the program would produce the following misleading dialogue:

```
USER:     Tell me about integer constants.
PROGRAM:  Do you want to know about integer
          constants as they relate to
             1) "definition"
             2) "range" and "real"
          or 3) "examples" and "real" ?
```

Figure 4.10
Dialogue Resulting from Erroneous Concept Graph

Two types of nodes are used to permit the analyst to indicate the co-occurrence of several subconcepts without requiring an explicit list of copies of the relevant subgraphs. A category node represents a set of references pertinent to the interplay of the ideas represented by its ancestors. In the examples shown above (except for the erroneous concept graph in Figure 4.8), all nodes have been category nodes.

On the other hand, a co-occurrence node is relevant to each ancestor individually. A co-occurrence node denotes that all its ancestral concepts, regardless of any interaction of their meanings, are pertinent to the indicated passages. Ancestors of these nodes are concepts that happen to be discussed in the same text segment.

A category node descended from "summer" and "rain" might refer to text segments describing rainy summer days. In contrast, passages such as "One hot summer day, Joe Smith dreamt of rain" or "Jean likes summer and Sue likes rain" would not be included. However, a co-occurrence node with the same ancestors could point to all these passages.

Co-occurrence nodes are abbreviations. A co-occurrence node can be removed from a concept graph by placing a copy of the subgraph descendent from it under each of its ancestors. Using the convention that category nodes are

indicated with round shapes and co-occurrence nodes with rectangles, this transformation yields Figure 4.11 from Figure 4.7.

constant

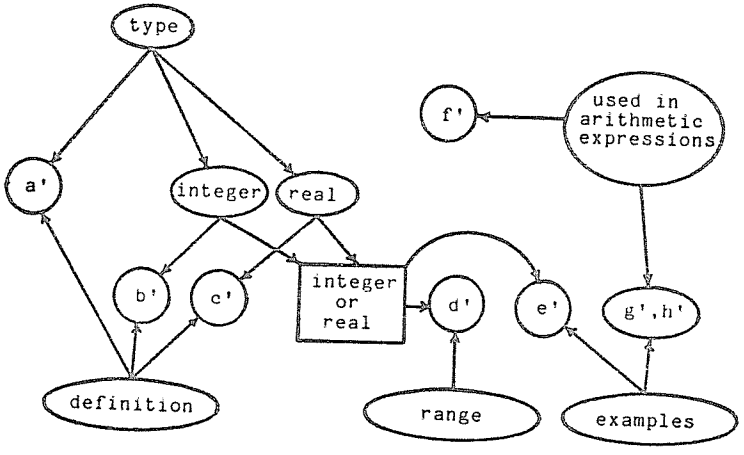


Figure 4.11 Example of a Co-occurrence Node

This new graph can be used to provide the sample dialogue shown in Figure 4.9. As the program examines the descendants of a selected node, it ignores other ancestors of co-occurrence nodes. Thus, starting from "integer", the only other relevant ancestors of the references to d' and to e' are the nodes marked respectively "range" and "examples".

4.3.3 Names and Functions in Concept Graphs

Each node in a concept graph, like the passages in the passage tree, may have one or more names and one or more functional labels. For example, a concept named "Alice" might fill the function of "protagonist". Names and functions have a tagmemic "slot-and-filler" quality [15]. However, unlike tagmemic units, nodes in a strep may have several identifiers, or none. In the sample concept graphs shown above, no attempt is made to distinguish between names and functional labels. Furthermore, redundant identifiers were used. For example, in the subgraph

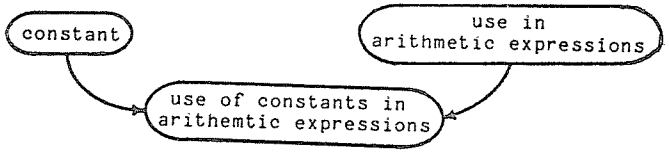


Figure 4.12 Redundant Identifiers in a Concept Graph

the identifier "use of constants in arithmetic expressions" is not really needed since it is implied by the identifiers on the parent nodes. The remainder of this paper uses redundant identifiers in the hope that they clarify examples for the reader.

4.3.4 Combining the Graphs of Several Concepts

All concepts pertinent to a given application could be represented by a set of concept graphs. There are two reasons to avoid this approach. The first is the difficulty of isolating independent concepts. The examples given in the preceding sections treat "the use of constants in arithmetic expressions" as a subconcept of "constant". The two concepts could have been encoded separately. In addition, "constant" could have been included in a graph for a more general topic such as "data". The second reason is that different graphs duplicate information. The graph for "constant" indicates that there are two types of constants: real and integer. A similar breakdown could be made within the graph for "variable", the graph for "arrays", and the graph for "input/output".

Both objections can be overcome by encoding all cross-references in a single concept graph, called the passage-dependent network. Some nodes in this network correspond to global concepts, others to subconcepts. Since it is never necessary to separate a concept from its subconcepts, the first objection disappears. Secondly, redundancy is eliminated by allowing nodes such as "type", "integer", and "definition" to point simultaneously to

subgraphs pertinent to several concepts. In the case of the hypothetical manual used above, the subgraph pertaining to constants might appear as follows:

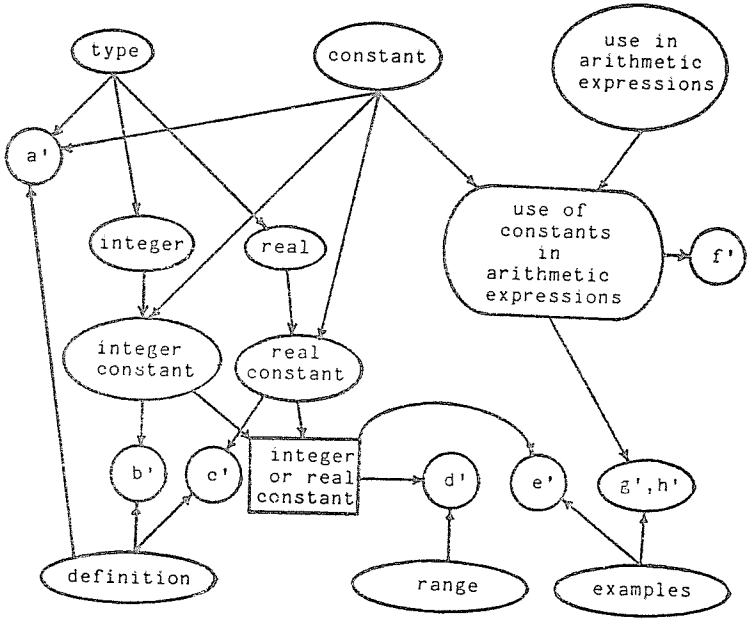


Figure 4.13 Portion of a Passage-Dependent Network

The entire network would probably contain other arcs emanating from the nonterminal nodes in this subgraph.

An individual concept graph can be identified within the passage-dependent network by locating the subgraph formed by the category node representing the concept, all

its descendants, and all ancestors of the category nodes among those descendants. The category node used to define a concept graph is called the head of that subgraph. Each descendant of the head is called a subconcept of the head concept. The remaining nodes in the concept graph are called modifiers of the head concept. A concept graph does not necessarily contain all descendants of its modifiers.

The terminal nodes in Figure 4.13 are subconcepts of the concept graph for "constant". All other nodes, except the head node itself, are modifiers. Assuming the network includes other references to all these modifiers, no proper nontrivial subgraph of Figure 4.13 is a concept graph. The node marked "constant" is a modifier in the partially-illustrated concept graphs for "definition" and "type". One of the concept graphs embedded in Figure 4.13 is the graph for "use of constants in arithmetic expressions":

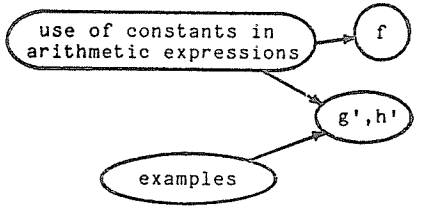


Figure 4.14
Concept Graph for
"Use of Constants in Arithmetic Expressions"

While this graph contains the node "examples" (as a modifier), it does not include the reference to e' that is descendant from "examples". The graph for "real constant" is also contained within Figure 4.13:

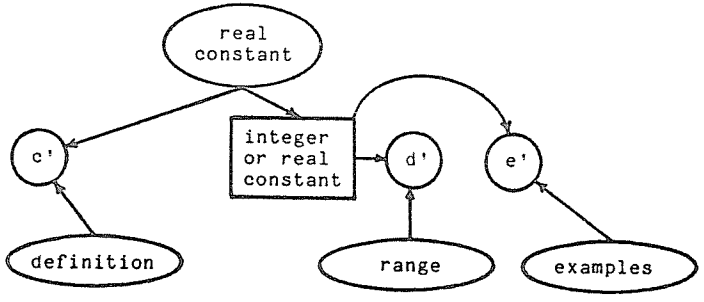


Figure 4.15 Concept Graph for "Real Constant"

This concept graph includes the co-occurrence node, but does not contain the "integer constant" ancestor of that node.

There is another advantage to encoding all cross-references in a single network. Concepts such as "constant" and "real" are different from concepts such as "definition" and "example". An analyst concerned with locating information views the latter ideas as subcategories of concepts of the former type. However, a researcher interested in the use of definitions within a class of documents treats the first type of concept as instances of the second. The same passage-dependent network can be used by both individuals. Nodes representing ideas in each class are modifiers in the concept graphs for concepts in the other class.

4.4 The Passage-Independent Network

Although semantic information is represented in the passage-dependent network, this graph is not a "semantic network" in the usual sense of that expression. The traditional semantic net represents meaning; the passage-dependent network uses meaning, supplied by the

analyst, to group passages of a text. Thus, Figure 4.13 shows that "integer constants" can be discussed in relation to "definition", "range", or "examples". It does not define "integer constant" as an entity with the properties "definition", "range", and "examples". The third component of a strep is a semantic network used to represent any structurally significant portion of a text's content. Unlike the passage-dependent network, this network is a semantic net in the usual sense of the phrase.

This network is called the passage-independent network because the information encoded within it is not explicitly bound to specific passages of the document. In fiction, family relationships among the characters typically have this property. Propp [56], for one, considers some family relationships important to the structure of folktales. This information could be encoded only awkwardly in the passage-dependent network. In a strep for the familiar fairy tale "Hansel and Gretel", a reference to the sentence "Hansel took his sister's hand" could be used to indicate the children are brother and sister. However, the reference could not have the same significance if the sentence were replaced by "Hansel took Gretel's hand". In applications that require this information, the passage-independent

network allows it to be specified in a manner that is independent of simple variations in the text.

Other relationships among recurring elements can be encoded in the passage-independent network. For programming manuals, the passage-independent network can indicate parameters used by different routines, options used on various programs, different language constructs that can employ a given sub-construct (e.g., statements that can contain arithmetic expressions), or the range of values a data structure may acquire. Streps for various types of instructions (e.g., recipes, assembly directions for a bicycle, knitting patterns) can indicate tools used in different tasks. For history books, a president might be associated with the time period he was in office. Geographic data (e.g., distances between cities, identity of state capitals) might also be encoded.

The information in the passage-independent network need not all pertain to concepts identified in the passage-dependent network. Relations among passages in the passage tree can be indicated; possibilities include implication, cause and effect, and simultaneous occurrence. To represent the flow of time in an event-oriented text, all three components of the strep are needed. For each point in time mentioned in the text, a concept is entered into the

passage-dependent network. This concept refers to the passages describing events that occur during the time period. The passage-independent network encodes the ordering of the different time periods.

Some applications for streps do not require a passage-independent network. Chapter 7 describes a system designed to utilize the information in the passage tree and passage-dependent network only. In certain instances, complex relationships can be indicated by functional labels in the passage-dependent network. In a strep for a fairy tale, there must be a concept filling the function of "hero" and another filling that of "villain". The conflict between the corresponding characters need not be encoded in the passage-independent network; it is implied by these functions. In a study of character roles in folktales, an analyst would presumably begin by creating a complete strep for each tale in some corpus. He would indicate the relationshsips among the characters in the passage-independent networks. Once he had examined enough data to form generalized role identifications, he could use labels for the identified functions to test his hypotheses on additional stories without encoding their passage-independent networks.

When it exists, the passage-independent network is part of the structural framework established by the passage tree and passage-dependent network. Some of its nodes correspond to concepts in the passage-independent network or passages in the passage tree. In fact, in the examples given above, the passage-independent network shows additional relations between concepts of the passage-dependent network. Because of this interrelationship, the entire strep may be viewed as a partitioned network [65] whose three main planes are the passage tree, passage-dependent network, and passage-independent network. Individual concept graphs may be viewed as subplanes of the passage-dependent network.

4.5 Adequacy of Streps

Chapter 3 identifies criteria for an adequate representation of text structure. This chapter has introduced such a notation and shown how the criteria of order, function, cross-reference, and flexibility are met by the strep. The ability of the strep to satisfy other criteria is demonstrated in succeeding chapters. It is appropriate to review the criteria in turn and describe how each is satisfied by the strep.

practicality: This property can be demonstrated by implementation of an economical system using streps. Although no such implementation has yet been undertaken, Chapter 7 thoroughly describes one such program and Chapter 8 mentions several other possibilities.

generality: Of the four complete examples given in the next two chapters, none uses a text written in expectation of analysis by strep. The examples represent four very different classes of text: a Russian fairy tale, a science book for young readers, internal documentation for a set of computer programs, and a user's manual. Although three of the texts were written in English, the fourth is a translation from the original Russian.

order: As illustrated in this chapter, the passage tree encodes the order in which ideas are presented in the text.

function: Functional labels attached to the nodes in the passage tree identify the function served by portions of the text.

cross-reference: The passage-dependent network associates appropriate portions of the document with recurring entities.

flexibility: Many different streps are possible for one text. The manner of connecting the passage tree to the text, the number of divisions shown in the passage tree, the specific concepts shown in the passage-dependent network, the names and functions identified, and the relationships encoded in the passage-independent network may all vary. This flexibility allows the analyst to encode only relevant structural features.

completeness: The applicability of streps to entire texts is demonstrated by the examples in Chapters 5 and 6. The partial examples in the current chapter are intended to show that each of the structural features described in Chapter 2 can be encoded.

incrementality: For successful use with programming manuals, it must be possible to update a strep with minimal effort each time a text is revised. Chapter 7 describes a method of combining a strep-generator with a word-processing system in order to simplify concurrent updating of both strep and text.

The next chapter demonstrates the generality and completeness of the strep notation by applying it to two complete texts.

5. Two Detailed Examples

5.1 Introduction

This chapter describes possible streps for two different texts: a Russian folktale and a science book for young readers. The passage trees and passage-dependent networks are discussed in detail. Because the passage-independent network is highly dependent on an individual application, a possible passage-independent network is described here only for the first text. The bodies of the selected texts and the completed passage trees and networks are too bulky to be included in entirety here; this material is presented in Appendices A and B.

5.2 Frolka Stay-at-Home

5.2.1 The Story

The first example shows that Propp's analysis [56] of a Russian fairy tale can be embedded in the strep notation and that this notation easily permits elaboration of the analysis. On page 128, Propp presents a summary of a sample story with a kidnapping theme. The tale he selects is numbered 131 in the fifth and sixth editions of Aleksandr Afanasev's Narodnya Russki Skazki, the definitive collection of Russian folktales. In English, the story is called "Frolka Stay-at-Home".[1] A translation of the story is presented, segmented into passages, in Appendix A. Propp's summary, with explanations of his symbolism is shown below:

(1) A tsar, three daughters (α; Setting).

(2) The daughters go walking (β^3; Absentation of Younger Generation),

1. Norbert Guterman has translated many of the Afanasev tales into English. Although the original enumeration of the stories was not preserved in the translation, it seems clear from the summary that No. 131 is the story Guterman titles "Frolka Stay-at-Home". Prof. James O. Bailey of the Department of Slavic Languages at the University of Wisconsin at Madison has kindly taken the time to confirm this identification.

(3) overstay in the garden (δ^1; Violation of Implied Interdiction).

(4) A dragon kidnaps them (A^1; Villainy in the Form of Abduction).

(5) A call for aid (B^1; Mediation in the Form of a Call for Help).

(6) Quest of three heroes (C; Counteraction and $\uparrow$; Departure of heroes).

(7) Three battles with the dragon (H^1; Struggle, $_1$ in the Form of Battle in Open Field--I^1; Defeat in the Form of Villain Beaten in Open Combat),

(8) rescue of the maidens (K^4; Object of Quest Obtained as Direct Result of Preceding Action).

(9) Return ($\downarrow$; Return of Hero),

(10) reward (w^0; Monetary Reward).

Figure 5.1 Propp's Summary of "Frolka Stay-at-Home"

Concatentation of the symbols identified with each element of the summary (except the setting, which does not correspond to action in the story), yields Propp's description of the structure of the text:

$$\beta^3\ \delta^1\ A^1\ B^1\ C_{\uparrow}\ H^1\text{-}I^1\ K^4{}_{\downarrow}\ w^0$$

Figure 5.2 Propp's Notation

5.2.2 The Passage Tree

This section is not intended as a criticism of Propp's work. Propp achieved his goal by exhaustively categorizing the events in Russian folklore and defining order restrictions on the resulting functions. It is only for other applications, such as generation of full-length natural-sounding stories, that a more complete analysis is required.

The passage tree corresponds to Propp's linear string. Propp's analysis and terminology can be preserved in the strep notation by using his symbols, or their descriptive titles, as functional labels on the nodes of the passage tree. With a direct translation, the tree would have eleven nodes: the ten leaves would be direct descendants of the root and each leaf would correspond to an item of the summary shown in Figure 5.1.

Although a tree formed in this manner would accurately duplicate Propp's description, its passages could not be associated with text segments in the manner chosen in Chapter 4. Propp's string is effective as a summary of the story, and it does indicate the order in which events occur. However, the text cannot be rigorously segmented so that consecutive passages correspond to consecutive symbols in

his string. The problems are minor and result from Propp's use of a linear notation to represent a tree structure. Very simple extensions to the original analysis permit a segmentation of the story to be associated with a passage tree in a manner that preserves the functions identified by Propp.

The most serious discrepancy between the order of events in the story and in the summary involves the order of the battles with the dragons and the rescue of the princesses. The summary indicates that all the fighting occurs before the rescue is accomplished. In the folktale, however, each battle results in the release of one of the maidens.

The three-fold repetition of story elements is very common in folklore. Propp mentions trebling but does not dwell on a topic that "has already been sufficiently elucidated in scholarly literature" (p.74). According to a strict interpretation of Propp's rules, "liquidation of a misfortune" (rescue of a princess) cannot be followed by a struggle between the hero and a villain. Recognizing this story is well-formed even though a battle follows a rescue, Propp summarizes these events with the phrase "three battles with the dragon" followed by "rescue of the maidens" and

does not mention that these events are actually intercalated.

When structure is represented by a tree instead of a linear string, the order restrictions can be stated with respect to subtrees. The rule mentioned above can be rephrased as "a node denoting liquidation of misfortune cannot be followed by a sibling that denotes a struggle between a hero and a villain". This rule allows structures such as the following:

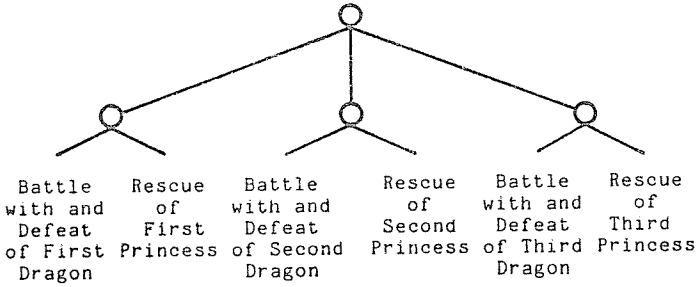


Figure 5.3 Accurate Representation of the Three Battles

This figure represents the events in the story more accurately than does Figure 5.2.

Other discrepancies between the order of events in the story and in the summary are less significant. For example, Propp indicates that the "absentation of younger people" precedes the "violation of implied interdiction". Both

functions are indicated in the translated tale by the single sentence, "One night the king's daughters tarried in the garden..."; neither function precedes the other. When the text is segmented to form the passage tree, this situation can be indicated by assigning both functional labels to the segment containing this sentence.

Propp himself uses multiple identifiers on a single passage. In the summary, for instance, the quest of three heroes is marked both "Consent to Counteraction" and "Departure of Heroes", and the battles are labelled both "Struggle in the Form of Battle in Open Field" and "Villain Beaten in Open Combat." Nevertheless, the tree shown in Appendix A does not use the multiple labels that Propp does. The "Consent to Counteraction" and "Departure of the Heroes" are indicated by separate clauses in the text:

Three men agreed to undertake this task...

and

and they set out to look for the princesses.

In the passage tree, each clause forms a distinct passage and is individually labelled.

In the other case, the advantages of a tree structure are used to distinguish between a battle and a villain's defeat. It would be inaccurate to claim that the defeat follows the battle; the defeat is part of the battle. Propp

has solved this problem by combining the two functions. In the tree, however, the passage corresponding to each battle has two descendants: one for the beginning of the battle, one for its conclusion.

The tree structure can also indicate other function-subfunction relationships. Propp obviously felt that the hero's counteraction to the act of villainy was important; therefore, he identifies the "Consent to Counteraction". In a linear notation, he cannot indicate the functions that combine to form the counteraction. However, in the passage tree, the events from the "Consent to Counteraction" through the final rescue are grouped together as descendants of a node labelled "Counteraction".

Although Propp's work is a classic in the field of folklore, it is by no means accepted as definitive. Bremond [9] points out that Propp's functions do not account for many types of similarities among fairy tales. Propp's analysis, for instance, does not classify "Frolka Stay-at-Home" as a story about dragons. In addition, a purely functional analysis overlooks similar episodes that serve different purposes (e.g., depriving someone of food may be an act of villainy in one story and the villain's punishment in another.)

The Aarne-Thompson Tale-Type Index [1] is another well-known classification of fairy tales. This index is divided into Animal Tales, Ordinary Folktales, and Jokes and Anecdotes. These categories are subdivided; the Ordinary Folktales, for example, include Tales of Magic, Religious Tales, Romantic Tales, and Tales of the Stupid Ogre. Dundes [18] has two major objections to the Aarne-Thompson approach: 1) this scheme does not uniquely classify stories that involve, say, both an ogre and a magic object and 2) this scheme does not show similarities between essentially identical stories in which, for example, a fox tricks a bear or a man tricks an ogre.

The strengths and weaknesses of Propp's method are complementary to those of Aarne and Thompson. The strep notation allows both views to be represented. "Frolka Stay-at-Home", for example, can be classified as Tale-Type No. 300, "The Dragon-Slayer", or as Tale-Type No. 301, "The Three Stolen Princesses". These additional functions can be assigned to appropriate nodes of the passage tree as shown in Appendix A. The resulting strep then encompasses the Aarne-Thompson classification as well as an augmented version of Propp's analysis.

5.2.3 The Passage-Dependent Network

Although the passage tree formed in the preceding sections includes all the information shown in Propp's descriptive string, it is not complete. Propp mentions the roles played by the characters in a story and the events in which they participate. His notation, however, does not encode these data. The passage-dependent network shown in Appendix A includes this information.

Just as Propp's summary neglects the repetition of the battles, it does not indicate that more than one dragon is involved in the story. Although the actual kidnapper is identified simply as a "dragon from the Black Sea", the oldest princess is rescued from a five-headed dragon while her sisters are held by monsters with seven and twelve heads. With nodes for each dragon (all descended from a single villain node), the passage-dependent network can easily describe the role of each dragon.

To illustrate other possible uses of the passage-dependent network in the analysis of folktales, Appendix A also identifies passages in which characters speak about each other and passages describing events that occur in different locations. Systematic inspection of these concepts for a large number of folktales might reveal

structural rules for this class of texts in addition to those already identified by Propp.

5.2.4 The Passage-Independent Network

The passage-independent network shown in Appendix A encodes the relationships that define the functions served by various characters. For example, Frolka is a hero because he fights the dragons and rescues the princesses. The network also shows relationships among the various trebled elements: relative age of the princesses, number of dragons' heads, distance between each dragon's home and the tsar's kingdom. With the associations between characters and text segments provided in the passage-dependent network, and with the assumption that textual and temporal orders coincide in this story, these relationships in the passage-independent network show that the princesses are rescued in order of decreasing age, the dragons are encountered in order of increasing number of heads, and so on. Again, similar networks for other stories might reveal consistencies in these structual features across the genre.

5.3 When an Animal Grows

5.3.1 The Text

The second sample strep describes a nonfiction book for beginning readers. A children's book was selected as a short text that is nonetheless long enough to present a nontrivial example. To emphasize the generality of the strep notation, nonfiction was chosen in contrast with the fairy tale discussed above. Despite the fact that streps are normally designed for a definite purpose, no specific application is discussed here. Streps for children's books could be used for many types of research. Classification of the structures of existing children's books (analogous to Propp's or Aarne-Thompson's classification of the structure of fairy tales) is one possibility. Psychological experiments dealing with children's recollection of stories is another; the structures of the recalled versions can be compared with that of the original. Structural factors could be incorporated into a measure of readability: can a child of specified reading ability comfortably read a particular story? Of course, more detailed texts intended for older audiences can have organizations similar to that of the text discussed here.

When an Animal Grows contrasts the growth rate of different animals. It begins with a description first of a newborn gorilla and then of a newborn lamb. Next it discusses the gorilla at three months and then returns to the lamb at a few weeks of age. The text continues to alternate descriptions of the two animals throughout their growth. A similarly-organized discussion of two species of birds follows.

A typical section about an individual animal begins with its age (e.g., "The baby gorilla keeps growing. He is six months old now.") and continues with a description (e.g., "He is still getting milk from his mother, but he is eating more and more plants). Sometimes there are several text segments dealing with one growth period. The section about the newborn mammals describes the eating and sleeping habits of first the gorilla and then the lamb. It continues with a discussion of the position of the mother and baby gorilla within the band of gorillas followed by a description of the relationship of the lamb and her mother to the flock of sheep. Mention of the animals' age is not repeated in succeeding segments about each stage of growth.

Variations in the pattern of alternation occur. The gorilla matures more slowly than the lamb and some sections about the former have no counterpart describing the latter.

5.3.2 The Passage Tree

This text is easy to segment. In fact, the book is printed in two colors so that all passages relating to the gorilla (and the ducks) appear in brown ink and the sections describing the lamb (and the sparrows) are written in green. These color changes dictate some of the segmentation needed to form the passage tree. The hierarchy of passages shown in Appendix B is, however, more complex than a linear division by color alone.

Nodes near the root correspond to long sections that include both colors. The text following the brief introduction, for example, is divided into a section on mammals followed by a section on birds. The first subsection of the former deals with the newborn animals. This portion in turn is divided into a segment on eating and sleeping followed by a segment on relationships with other animals of the species. Each of these divisions is broken into a terminal segment in brown about the gorilla and one in green about the lamb.

The leaves of this part of the passage tree correspond to entire segments of a single color. However, in other subtrees, several terminal passages may be formed from one section printed in a single color. Typically, a

single-color passage may be divided into a statement giving the animal's age followed by a description of its abilities at that age. Sometimes these descriptions are further segmented. In the discussion of birds, for example, the finer divisions of the passage tree are used to encode the fact that the same features are discussed in the same order for both species. The following section of the text is segmented into the named passages shown in Figure 5.5:

a) The little sparrows are in a nest hidden in the grass. They are tiny and helpless.
b) They have no feathers.
c) They can't see.
d) They can't walk.
e) How different the ducklings are.
f) They have soft little feathers.
g) They can see.
h) the mother duck leaves the nest. The little ducks follow.

Figure 5.4 Some Leafs in the Passage Tree

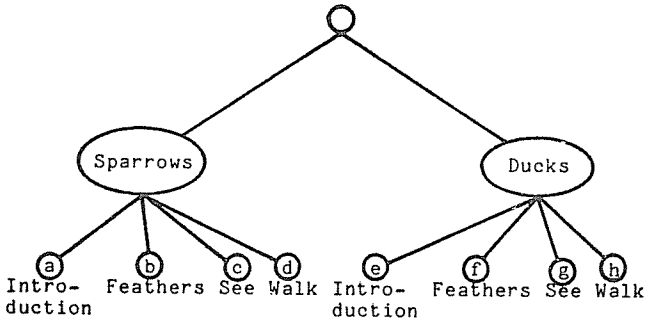


Figure 5.5 The Corresponding Subtree

Even with as rigorously organized a text as this one, it is not always clear how a particular passage should be segmented. Consider the following passages:

a) The baby gorilla gets less and less milk from his mother. By the time he is a year and a half old, he eats only stems, roots, and leaves...
b) The little lamb nurses only for a few months...
c) ...When she is a year old, she can have a little lamb of her own.
d) But the baby gorilla is still growing...

Figure 5.6 Weaning and Becoming Adult

Since b and c both deal with the lamb, the following subtree indicates a possible hierarchy over these passages:

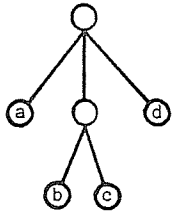


Figure 5.7 One Possible Subtree

This segmentation is supported by the author's use of colored ink: passage a forms an entire brown segment, b and c together form a green segment, and the following brown section begins with d.

Nevertheless, an alternate segmentation seems slightly preferable. Passages a and b both deal with weaning; c and d are concerned with reaching maturity. This section consists of the concatenation of segments on these topics, with the usual order of gorilla and then lamb reversed in the second subdivision. The hierarchy shown in Figure 5.8 reflects this grouping

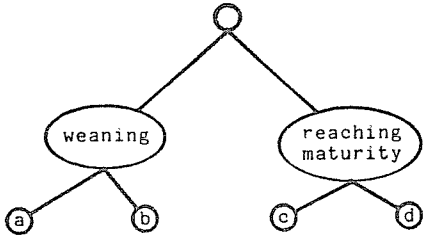


Figure 5.8 Another Possible Subtree

The structure of this section of the text cannot be completely described by a division into nonoverlapping segments. However, within a strep, either tree can be used successfully, because whatever information is omitted from the passage tree can be supplied in the passage-dependent network. If Figure 5.7 is selected, the concept of "weaning" should relate passages a and b; if Figure 5.8 is used in the passage tree, the concept "lamb" should refer to both b and c.

5.3.3 The Passage-Dependent Network

Concepts in the passage-dependent network presented in Appendix B relate discontinuous passages with a common theme. Each species of animal has a node. The concept of "age" is represented by a node that points to every passage

where the age of one of the animals is mentioned. The concept of "diet" links the passages that describe how the diet of each animal changes as it matures and also connects passages dealing with the diets of different species. Some more abstract concepts have been identified. For example, "moving" has descendants marked "standing", "walking", "crawling", "climbing", "swimming", and "flying". These specific types of movement eventually refer to passages describing the physical abilities of the different animals.

Although the network contains more than a hundred nodes, few of these concepts co-occur. In fact, most nodes in the passage-dependent network have only two parents. This situation results from the fact that most leaf passages describe only one feature of a single species. A concept referring to such a passage has one parent indicating the species and one parent indicating the feature. For example, when the concepts "sparrows" and "feathers" refer to a particular passage, none of the concepts, "ducks", "lamb", "seeing", and "being fed" refer to the passage as well.

5.3.4 Final Remarks

Although the names given to concepts in the passage-dependent network have strong connotations, the passage-dependent network and passage tree record the organization of the book rather than its content. Essential aspects of the meaning of the text are not encoded by these data structures. The theme of the book is explicitly stated in the first few pages:

> Some animals grow slowly, like the gorilla that is helpless at first. And some grow fast, like the lamb. Birds grow in different ways, too.

The rest of the book presents evidence that animals grow at different rates. The cumulative effect of the statement and proof of an idea is not encoded in the strep shown so far. It may be possible to represent this effect by a complicated construct within a traditional semantic network such as the passage-independent network.

However, no passage-independent network is shown in Appendix B. The passage tree and passage-dependent network adequately reflect the general form of the text. In a sense, the information shown is independent of the meaning of the text. A text with completely different subject matter could be organized in a similar fashion. With the names appropriately changed, nodes near the root of the

passage tree and most of the passage-dependent network could still apply. For instance, a children's book describing the seasons of the year might begin, "Now it is winter. The trees have no leaves. Now it is summer. Branches are covered with leaves and the grass is green. In winter, it is cold outside. In summer, it is warm..." (In fact, many other existing texts have an alternating pattern. William Faulkner, for example, preferred to have his two novels, The Wild Palms, and The Old Man published with the chapters intercalated. A strep for this book, like the strep for When an Animal Grows, should reflect this pattern).

6. The Structure of Programming Manuals

6.1 Introduction

This chapter investigates the structure of programming manuals. Constructs that frequently appear in texts of this class are discussed. Methods for representing these organizational patterns in the strep notation are presented along with a list of functions that identify these forms in passage trees and passage-dependent networks. Some of the functions mentioned here also apply to broader classes of documents. Cross-referencing, for example, which is discussed in detail in Section 6.4, appears in virtually every type of technical writing and in many fictional texts as well. The chapter concludes with the analysis of two short manuals. Although the selected documents are about the same length, their structures are very different. This difference is reflected in their streps, whose passage trees and passage-dependent networks are given in entirety in Appendices C and D.

6.2 Features of User Documentation for Computer Programs

It would not be possible to define a list of functions for reference manuals, analogous to Propp's work on folklore, that exclusively characterizes all material within a document and prescribes the order in which information can be conveyed. Nevertheless, many similarities can be observed in samples from a class of documents that includes tutorials on statistical packages intended for naive users as well as terse commentaries on formal definitions of structured languages. Figure 6.1 lists some types of material that frequently occur in technical documents. Figure 6.2 enumerates typical elements of programming documentation.

chapter/section/subsection
title/section heading
table of contents
index
appendix
glossary
figure
table
footnote
revision
erratum
introduction
conclusion
body
definition/description
example
acknowledgement
limitation
exception
bibliography
reference to another document
reference to another section (including "see above")
suggestion
intra-document conventions (schemes for numbering
sections, notation, summary of organization, etc.)

Figure 6.1

Some Structural Features that Frequently Appear
in Technical Documents

programs
files
data structures
control structures
identifiers
internal representation
input/output
operations/processes
options
syntax
semantics
subroutines
parameters
default values
calling sequence
order of commands
input conventions (e.g., columns 73-80 ignored;
statements terminated by by ";", etc.)
conventions and style (e.g., indentation, conventions
for choosing identifier names)
control cards
deck set-up
timesharing/batch
implementation
system change
hardware
cost
efficiency
error handling
error messages
debugging
maintenance
mechanics of running (e.g., where to submit a deck)
syntax summary
reserved words
character set
collating sequence

Figure 6.2

Typical Features of Programming Manuals

The entries in Figure 6.2 are very general. More specific features can be listed for restricted classes of documentation. Manuals on algebraic languages, for instance, contain sections on the assignment statement and the IF statement. Some features are specific to the documentation of a single manufacturer. Manuals for programs run on a UNIVAC 1100 series computer, for example, use "qualifier" and "element" in a manner that would be meaningless in another context. Some features of documentation are specific to an individual installation: many of the manuals produced at the Madison Academic Computing Center refer to a local concept, the "saved file". In all these cases, the concepts listed appear in many texts. Because of their frequency, it is important to recognize these features in an application that involves description of existing texts, generation of new texts, or location of material within texts.

6.3 Functional Labels in the Passage Tree

Most of the features mentioned in Figures 6.1 and 6.2 can be identified in a strep with functional labels on the nodes of the passage tree. Care must be taken with

non-linear features such as footnotes, tables, and figures. As mentioned in Chapter 2, footnotes may be assumed to be embedded in the text at the point where they are first referenced. The same convention may be followed for tables and figures.

Passages often serve more than one function (e.g., a node may be labelled both "appendix" and "character set"); conversely, some functions are filled by several passages. There may be restrictions on the acceptable arrangements of passages with a given function. For example, only the left-most sibling of any subtree may be labelled "introduction". While this rule is easily described as a restriction on tree structure, rules for "appendix" are based on the linear nature of texts. A document may have any number of appendices. However, they must be grouped together; one follows the other after the main body of the text, but before any references or index. Restrictions on other features are less severe; definitions may appear almost anywhere except within bibiliographic entries; footnotes may appear anywhere except within entries in a bibliography or within other footnotes.

Knowledge of these and similar restrictions is essential in generating texts; it can also be used to check for errors in proposed streps for existing texts. Similar

properties can be used in evaluating texts. For example, a text in which no term is used before it is defined may be more readable than one where this is not the case.

The features listed in Figures 6.1 and 6.2 cannot be adequately described with identifiers in the passage tree alone. Functional labels are used in the passage-dependent network to group and cross-list instances of these functions. For example, the concept graph for a particular command is likely to contain nodes marked "syntax", "semantics", and "examples".

Furthermore, a function which is used in the passage tree in some streps may be used in the passage-dependent network for others streps. In a particular text, all acknowledgements (or all examples) might be grouped in a seperate section; in this case, the appropriate function should be indicated in the passage tree. However, these features may be scattered throughout a document, embedded in text sections that contain other material as well. In the latter situation, these contructs are best identified through the passage-dependent network.

6.4 Cross-Referencing

A "cross-reference" is a statement within a document about another part of the same text or about another text. This device is used by an author to suggest that relevant material exists elsewhere; some comprehension of the text is often required to locate the referenced passage. Cross-references occur very frequently in programming manuals. In the strep notation, a text is divided into passages, and it is natural to express cross-references as references to the passage tree.

Many cross-references, such as "explained in Chapter 6", "see Section 3.2", appear to identify the relevant node in the tree. On the other hand, "see page 37" does not fit a representation in which page boundaries are not encoded. In addition, this reference does not mean that all of page 37 is relevant to the current point; rather, it indicates that some logical portion, a passage, of page 37 is relevant. Similarly, "as will be shown below" could refer to any portion of the succeeding text. An author who uses one of these phrases assumes that the reader is capable of recognizing the intended passage with the help of a general pointer. Even references that seem to be quite explicit may, in fact, be vague. "Volume 13" may name an individual

passage in a tree; nevertheless, the sentence "This example is one of many similar cases treated in Volume 13" does not precisely pinpoint the location of the referenced discussion.

Several types of cross-references can be distinguished. In the first place, there are internal and external references. The former (e.g., "as will be shown below") indicate passages within the same document; the latter mention portions of some other text.

Secondly, there are essential and gratuitous references. An essential reference points to another section containing material that is relevant to the current passage but is not expressed within it; a gratuitous reference repeats information that is stated elsewhere. Thus, the sentence "The type of these parameters will be described in the next section" involves an essential reference; "as explained in the following section, the parameters to this routine are all integers" is a gratuitous reference. The writer of program documentation frequently must decide whether to repeat information included elsewhere or simply refer to it. Concise texts such as reference manuals characteristically avoid gratuitous references. Programming textbooks and other tutorial guides are more likely to duplicate important details.

A final dichotomy among cross-references is that of explicit versus implicit references. A semantic connection between two nonadjacent passages may exist in a text even if neither passage explictly refers to the other. This situation is called an implicit cross-reference. Suppose a user reads that a program will prompt for a job priority. Two versions of the accompanying manual may be identical except that the second omits the sentence, "The options are explained in Section 4" that appears in the first. In the first case, the reference to Section 4 is explicit; in the second, it is implicit. The reader of either document is likely to wonder about appropriate responses to the program's prompt. This minor variation of wording should not affect the strep.

An implicit reference may be assumed to exist between any two passages with a semantic connection. Another concept in the passage-dependent network often links the passages so that it is not necessary to explictly encode the implicit cross-reference in a strep.

Cross-references inherently involve two passages: the referenced passage and the passage containing the reference. To represent references in a strep, the roles of both passages must be indicated. This relationship between passages can be encoded in the passage-independent network.

However, if an application does not require the passage-indpendent network for other reasons, cross-referencing alone does not warrant its inclusion. Furthermore, the passage-dependent network provides a convenient mechanism for representing the pointer that is the essence of a cross-reference.

To encode this information in the passage-dependent network, a node corresponding to each cross-reference is included in the network. This node has two children: one, with a modifier labelled "referenced passage" itself has a child that terminates at the referenced section; the other child, modified by a node labelled "referencing passage" is used to identify the referencing segment. For example, the concept graph in Figure 6.3 can be used to show that Section 1.0 refers to Section 2.0.

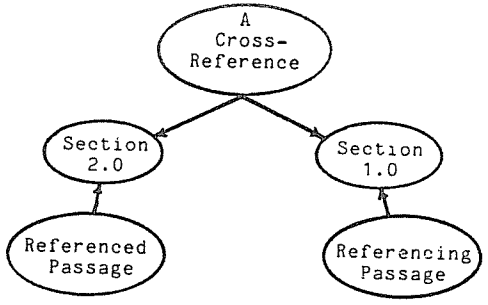


Figure 6.3
Encoding Cross-References in the Passage-Dependent Network

A more complex example, shown in Figure 6.4, presents an encoding for a manual where Sections 2.4 and 2.8 both refer to Section 3.0 while Section 3.0 in turn contains cross-references to Sections 1.7 and 4.2. An additional node "Cross-Reference" has been added in order to group all four references together.

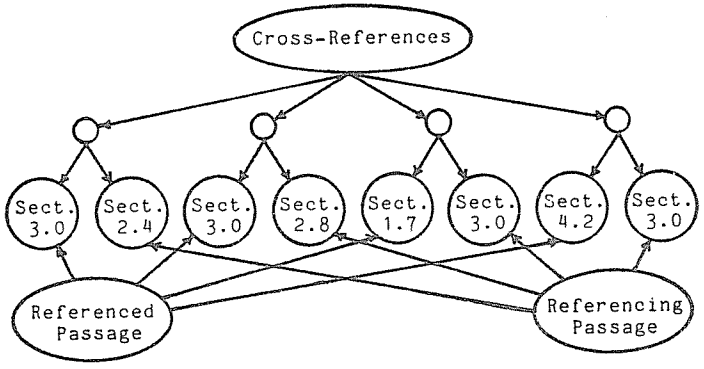


Figure 6.4
Several Cross-References Involving the Same Passages

Figure 6.5 reduces the number of nodes in Figure 6.4. A single node has been used to represent all references to a given passage. In addition, a co-occurrence node groups the pair of references from Section 3.0. The examples in Appendices C and D encode cross-references in a similar manner.

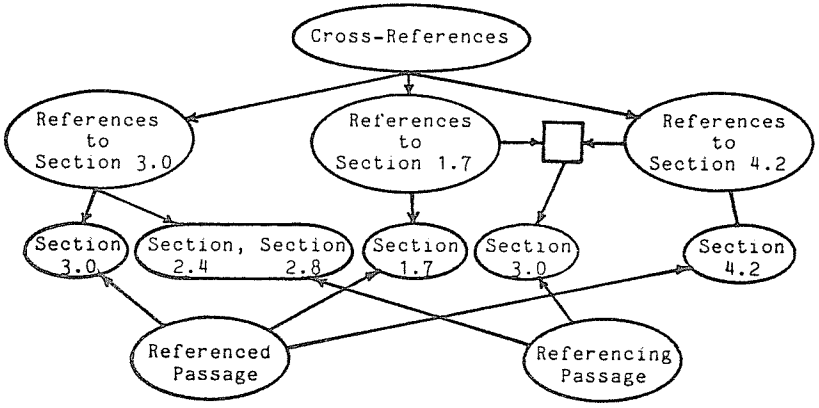


Figure 6.5 Reducing the Number of Nodes

6.5 Topic, Co-topic, and Mention

An idea can appear in a text as the primary focus of a passage, as one of several points treated in a passage, or as an issue mentioned in the context of some other subject. It is sometimes helpful to distinguish these possiblities in a strep with the functional labels, "topic", "co-topic", and "mention". In streps used for generating texts, this qualification provides a mechanism for identifying the

material to be presented in each passage. It is also helpful in retrieving selected passages from existing texts.

The size of the divisions made in the passage tree influences whether a concept will be a topic or co-topic in a given passage. When a text is broken into small portions, it is more probable that the leaves of the passage tree are concerned with single topics. The concepts discussed in introductions, summaries, and so on, are usually co-topics.

When a concept is mentioned in one passage, but is the topic of another, a cross-reference links the first passage with the second. In the earlier example about prompting for job priorities, the cited passage mentions "job priority" and also cross-references a section concerning this topic.

6.6 Two More Examples

Appendices C and D give the passage trees and passage-dependent networks for two short programming manuals along with the bodies of the texts. The items listed in Figures 6.1 and 6.2, the categories of cross-reference, and "topic", "co-topic", and "mention" identify the function of nodes in the streps.

The first manual is the ASCII FORTRAN Supplement, available at the Madison Academic Computing Center, as a local addition to the vendor-supplied programmer reference manual. The primary purpose of the ASCII FORTRAN Supplement is to provide information needed by users who are more familiar with another compiler, FORTRAN V, than with ASCII FORTRAN. The document discusses features provided by ASCII FORTRAN that have no counterpart in FORTRAN V and steps for interfacing between the two compilers.

The second example is based on the LEXICO Maintenance Guide. LEXICO is a system for maintaining collections of texts, concording individual texts and classifying the words that appear in the concorded texts. Several features of the system simplify further development and debugging; this document describes these capabilities. The Maintenance Guide is an internal document not intended for general users.

The two documents are about the same length, roughly fifteen pages. Each assumes its readers are experienced programmers with a thorough knowledge of material not presented in the document. Despite these similarities, the structures of the two manuals are very different. Some of the differences are immediately obvious in the passage tree.

Only the ASCII FORTRAN Supplement has a table of contents and uses examples.

The major difference is in the interaction among the concepts contained in each text. The ASCII FORTRAN Supplement is a list of independent topics. The LEXICO Maintenance Guide has some sections dealing with various data files and others describing the use of several supporting programs. Explanations of how a particular file is affected by various programs occur throughout several passages. Similarly, the one-letter codes used to identify described options have different meanings to different programs. Since a reader may be interested in any combination of option-letter, program, and file, names for these various entities are used as modifiers in the passage-dependent network. The result of this difference between the two texts is that, while the passage-dependent network for the ASCII FORTRAN Supplement contains 98 nodes, there are 269 nodes in the network for the LEXICO Maintenance Guide.

These two streps are used to provide examples of interaction with the on-line documentation system proposed in the next chapter. A few comments on some of the decisions made while encoding these structures are included in Appendices C and D.

7. THUMB

"All the documentation in the world can't replace somebody who knows what's going on."

--overheard in the halls of a computing center
June 21,1977

7.1 Introduction

This chapter describes the design of an on-line documentation system based on streps. The resulting set of programs, given the rather strained title, "Text Heuristics for Using Manuals Better"[1] allows a user to "thumb" through a manual interactively. THUMB is designed to operate even on manuals that are not written specifically for on-line use. The system does not exist as of this writing. Implementation of a similar system, using aircraft maintenance manuals instead of programming manuals, is scheduled to begin in June, 1978.

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1. The expansion of this acronym was kindly suggested by Prof. Raphael Finkel.

The system has two major components. The first subsystem, ENCODE, is used by an expert to build or modify a detailed strep for a document. No passage-independent network is needed in this application. The passage tree and passage-dependent network are supplemented by an extensive lexicon, relating keywords, key phrases (and their synonyms and plural and singular forms) to names and functions in the strep. The output from ENCODE is a file containing the lexicon, the passage-dependent network, the passage tree, the text segments associated with the leaves of the passage tree, and the necessary pointers for linking these elements. All arcs are represented by two-way pointers so that any part of the strep may be traversed in either direction. The following diagram indicates the flow of information through ENCODE.

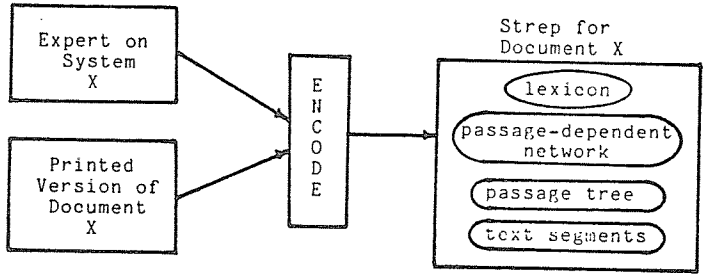

Figure 7.1 Information Flow Through ENCODE

The data structure output by ENCODE is used by PERUSE, the second component of THUMB. The user of this program, called the peruser, requests information interactively. He need know nothing about text structure, streps, or the decisions made by the expert who encoded a particular document. The peruser requests information using the vocabulary items stored in the lexicon. The lexicon provides access to the passage-dependent network through which pertinent portions of the passage tree are found. A successful search of the passage tree results in display of text segments associated with leaf nodes of selected subtrees. The operation of PERUSE is indicated in Figure 7.2 below.

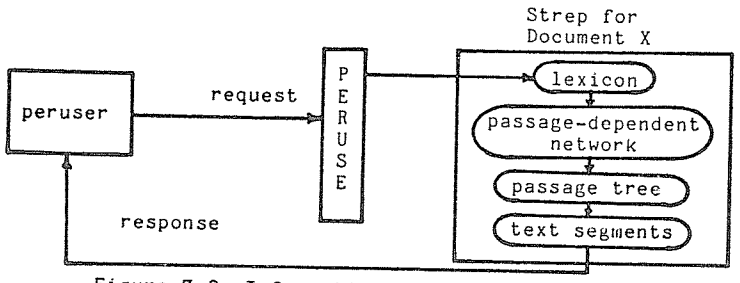

Figure 7.2 Information Flow Through PERUSE

The following section deals with the need for on-line documentation and describes existing systems whose capabilities are considered for THUMB. The succeeding section shows how PERUSE integrates selected features of previous systems as well as other capabilities. The final section in this chapter describes ENCODE and how the expert prepares a strep.

7.2 Motivation and Background

All computer users -- experienced users and novices, programmers and non-programmers -- depend on documentation. Because of the attention to fine details required when communicating with a machine, reference manuals are sometimes needed even by the most knowledgeable individual.

On-line documentation systems not only provide a convenient means of obtaining an entire document, but can also help locate elusive information within a particular text. Moreover, descriptions of system changes can be readily incorporated into on-line documents; updating all copies of printed documentation is more difficult and expensive.

As more people with varying degrees of computing experience use interactive programs, there is a growing need for on-line documentation. On-line documentation is not, however, intended only for novices. The experienced programmer does not use a manual at every terminal session, but can occasionally forget the details of a particular process or be momentarily confused by similarities between different systems. All users can benefit from interactive assistance. In particular, as Truitt and Emery [71] note, the increasing use of computer networks emphasizes the need for adequate user services, including on-line documentation. Remote users may not have ready access to printed documents and cannot turn to consultants as conveniently as can users of local systems.

Even when written documentation is readily available, the process of finding the answer to a specific question can require considerable effort. An interactive program that performs some of the record keeping required while flipping

between an index and the corresponding text benefits even the fortunate programmer with a terminal next to a full bookcase of up-to-date manuals.

Some interactive systems use analogues of conventional tools (the table of contents and index) for finding material within a document. The SPEAKEASY language [12, 13] developed at Argonne National Laboratory supplies on-line assistance in the form of "Help Documents". Although included as a bulky appendix to the user's manual, these paragraphs are written specifically for interactive use and are organized in a hierarchy whose tree structure is similar to that of a passage tree. A user who enters "HELP" is presented with a list of the major categories within the SPEAKEASY vocabulary. "HELP" followed by the name of a SPEAKEASY concept causes a display either of a list of the subconcepts at the next level in the tree or of an explanation of that term.

ZOG [49, 60], developed at Carnegie-Mellon University, displays sections of written material in an order determined by the individual user. This program is a generalization of the PROMIS system implemented at the University of Vermont for maintaining medical records. Robertson, Newell, and Ramakrishna [60] report that PROMIS has been used successfully by naive users. Each section displayed by ZOG

includes a list of relevant material that a user might wish to view next. Since more than one display may suggest a particular section as a possible next choice, the data are organized as a network rather than as a tree. ZOG maintains a stack to record the nodes that have been displayed during an interactive session. At any point, the user may backtrack through this stack. In addition, the user may mark certain nodes and return to the identified displays at a later time. These two features provide the user with a simple method of following alternate chains of thought from a common starting point.

Another program with some of THUMB's proposed capabilities is SEARCHER, which is used at the University of California at San Diego to dispense documentation on locally produced software [30]. SEARCHER locates sections of program write-ups to be displayed interactively or printed as a batch process. The stored material is organized in a tree structure. Each text section is given a multi-level identifier (e.g., 7.2.8.16) that includes a numeric field for each of its ancestors in the tree. In addition, a set of keywords is associated with each section. The user can ask for a list of the sections associated with any boolean combination of keywords. Any section of a document can be requested by its identifier. Any subsection of the current

focus (going down one level in the tree structure) is available without specification of its complete identifier. The user may also select material any number of levels above the current point. Finally, he may inspect portions of an alphabetized list of the keywords associated with a document.

The documentation for the algebraic language called FOSOL [24] is also organized in a tree structure, though its hierarchy is not as deep as in SPEAKEASY or ZOG. The FOSOL manual is divided into chapters that are identified by names without the conventional numbers. Each chapter is divided into sections called topics. The first topic in every chapter identifies the remaining topics. The command "HELP;" produces a list of chapter names. The user may also request HELP on an individual chapter, in which case the system prompts for topics. Copies of this interactively-oriented manual may be produced on a batch printer, but FOSOL has no other off-line documentation.

FOSOL has another interesting feature. Its interactive users may inspect any portion of the documentation at any time during a session. Furthermore, when certain types of errors occur, sections from the manual are automatically displayed.

Ideally, all interactive programs should have the capability of displaying on-line documentation. A user should not be required to end a session with a program in order to obtain information about it. FOSOL is not the only system to provide assistance of this type. Many other programs have a HELP command that explains error messages or briefly describes available commands. The LEXICO system [73, 74, 75, 76] provides several user aids. Whenever LEXICO issues an error message or prompts for data, the user may ask for one or more explanations of the message. This feature makes the system convenient for the novice without annoying the experienced user who requires less detail.

LEXICO's designers realized that the multiple explanations might not provide sufficient help for all users. The final level of each message therefore contains a reference to a specific section of the user's manual. (The LEXICO documentation was originally intended to be accessible interactively.) The inaccessibility of potentially useful material is not the only aspect of LEXICO's on-line documentation that can be improved. On rare occasions, the successively more detailed explanations can add to the user's confusion instead of alleviating it. During the development of LEXICO, a user once accidentally transmitted a line after typing only one character. This

character happened to be interpreted as a request for capabilities that the user did not know existed. The program responded with several questions that were incomprehensible to her. Unfortunately, the more detailed explanations she obtained dealt with the process she had inadvertently begun, and used vocabulary with which she was unfamiliar. She was therefore unable to return to the task she had been performing. PERUSE provides a user in similar circumstances with all necessary definitions. Given an initial message, it can provide more specific information (e.g., to a user trying to fix a syntax error) as well as more general information (e.g., to a user who is lost). The data encoded in a strep is used to locate the text sections containing these facts.

On-line documentation is supported by many other systems with commands similar to those of the varied programs described above. THUMB combines and expands these capabilities. PERUSE provides interactive users with all the information available in off-line documents. As will be shown in the next section, it responds to different types of requests in a consistent fashion and is easy to use. The tree-searching capabilities of several of the other programs are included in THUMB. As with SEARCHER [30], keywords can also be used to access material. PERUSE allows the reverse

process as well; it can display a list of the concepts associated with a particular passage. The browsing capabilities provided by ZOG's stack are extended in PERUSE. While ZOG users search through a prepared network, the choices provided by PERUSE are dynamic, determined by the keywords in the user's request. In addition, PERUSE allows readers to follow cross-references and to relate on-line displays to hard-copy manuals by page number. The advantages of each of these features are enhanced by their combination.

7.3 PERUSE

7.3.1 Overview

This section describes the PERUSE program used to display passages of text. There are two ways to access PERUSE. The first possibility, in which PERUSE is a separately executable program, allows perusers to initiate a terminal session in order to obtain documentation. Figure 7.3 illustrates this implementation. Solid lines indicate the flow of information as a peruser inquires about some

program, System X. Dotted lines indicate possible flow for inquiries about other programs.

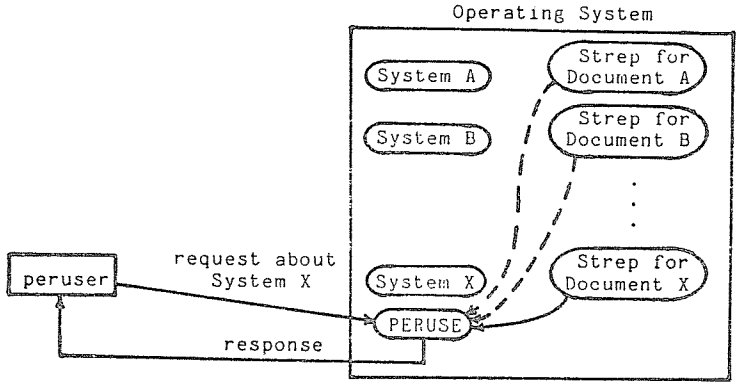

Figure 7.3 PERUSE As a Separate Program

The second approach, represented in Figure 7.4, allows any program in the system to invoke the capabilities of PERUSE. In this form, users can access PERUSE without interrupting a dialogue with another interactive system.

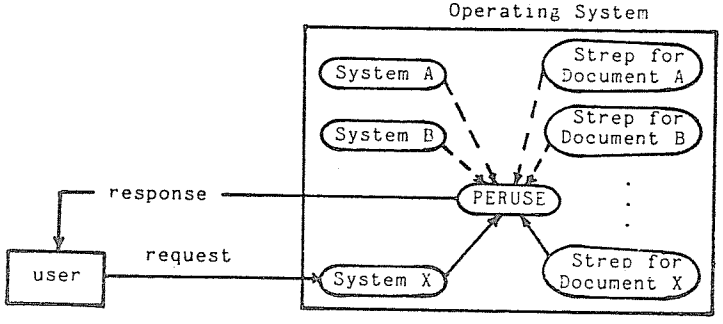

Figure 7.4 PERUSE Accessible from Other Programs

The current proposal concentrates on the capabilities of THUMB and leaves the task of integrating this system into others for future work.

The usability of THUMB depends in large part on the syntax of PERUSE commands. The peruser is primarily interested in the target system; everything he has to learn about THUMB is distracting. A restricted natural language format is desirable. PERUSE should be able to respond to questions like

> Where are parser options defined?
> What options does the parser program have?
> Define the possible options on the parser.

There is no need for PERUSE to accurately decode every input. When an ambiguous request is made, the peruser can be prompted for clarifying information. Keyword recognition schemes (where words in a request are ignored if they do not

appear in a special purpose dictionary) have been successful in similar situations. This approach was used, for example, in the GUIDE program for selecting PLATO IV computer science lessons [54] and in Project Genie [59].

Using similar techniques, PERUSE could translate natural language input into a more formal command language. As convenient as this would be for the user who is not familiar with the implementation of PERUSE, the sophisticated user (for example, an expert familiar with ENCODE) who sometimes finds natural language ambiguous and unwieldy might prefer to express requests more concisely in the command language. The peruser should be able to enter requests in either form, as indicated in the diagram below.

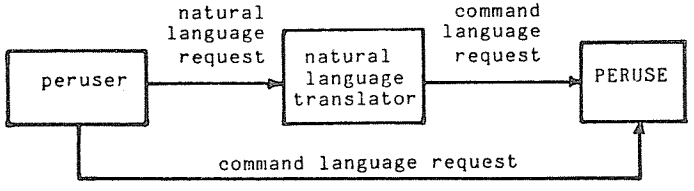

Figure 7.5 Alternate Forms of Input

In the following material, the capabilities of PERUSE are described in a tentative command language. The emphasis is on the effects of commands and not their syntax. Error handling, batch output, and options for long or short

display formats, although important in a practical implementation, are not described here. As with the integration of PERUSE into other programs, the designs of the natural language interface and an extended command language are left for a later project.

Three general categories of commands exist in the command language: those that use the relationships in the passage-dependent network to define a set of related passages, those that refer to specific passages, and those that solicit information in the passage-dependent network pertinent to a particular passage. These commands can be explained without using the phrase "passage-dependent network". The documentation for PERUSE will simply state that a user may ask the program for a list of passages pertinent to selected concepts.

PERUSE sometimes identifies several passages or concepts that the user might wish to investigate further. For example, if a user inquires about a concept that is pertinent to non-adjacent passages, or asks for cross-references from a passage that refers to two or more other sections, the program produces a numbered list of the relevant passages. Similarly, if the peruser asks to see a passage that has several subpassages, the program lists these subpassages. When such a choice point is encountered,

the user may select any of the listed possibilities. The result may be another choice point, or a single passage. If it is a single passage, PERUSE indicates its length and asks the user if he wishes to have it displayed. Some commands -- FIRST CHOICE, NEXT CHOICE, etc. -- allow the user to inspect several alternatives from a given choice point. The RETURN command enables him to resume at a previous choice point. In addition, other commands -- FIRST SECTION, NEXT SECTION, etc. -- allow the peruser to scan adjacent sections of text in their written order.

The alternatives listed at a choice point may be concepts as well as passages. When inspecting a concept graph in the passage-dependent network, PERUSE lists modifiers of the concepts selected by the user. If the user's choice is one of these modifiers, the response is a list of children of the modifier that fall within the original concept graph. Again, these actions can be explained to the peruser without reference to a strep: PERUSE lists concepts that can be used to distinguish among the identified passages.

Although the statements in the command language are described later, a sample session is given immediately below to illustrate some of the system's salient features. The reader of this paper may wish to glance through the example

now and return to it after reading the ensuing material. The dialogue is based on the strep for the LEXICO Maintenance Guide shown in Appendix D. User inputs are underlined and preceded by the prompt character, '>'. Displayed passages are surrounded by asterisks.

```
>ABOUT options

   Related Concepts:
     1.  Description
     2.  Setting Parser Options
     3.  Parser Options that are Reserved Words
     4.  Subconcepts of "Individual Programs"
     5.  Subconcepts of "Individual Options"

   Passages:
     6.  P9  Section 2.2  Options (13 lines)
     7.  P17 Section 3.  Options (63 lines)

>2

   Choice 2.  P9  Setting Parser Options
          Section 2.2  Options (13 lines)
          Page 2 Line 19 through Page 3 Line 4
   Display?

>YES

**************************************************************
*                                                            *
*     Parser options (which are listed in Section 3.1) may   *
*                                                            *
* be set on the control  statement  or with  either of the   *
*                                                            *
* commands                                                   *
*                                                            *
*       ROUTE 1005;                                          *
*       OPTION olist;                                        *
```

Figure 7.6 Sample PERUSE Session (Page 1)

```
#                                                                #
# Both commands may be entered in any block. The former          #
#                                                                #
# causes a display of all available options followed by          #
#                                                                #
# prompts for the options to be changed. In the latter           #
#                                                                #
# command, olist is a list of letters and numbers                #
#                                                                #
# indicating options whose on/off flags are to be                #
#                                                                #
# reversed. Reserved words appearing within olist must be        #
#                                                                #
# enclosed in quotes. d and s are reserved throughout            #
#                                                                #
# the system and t is reserved in EDIT blocks.                   #
#                                                                #
##################################################################
```

>Choice+2

```
   Choice 4.  Subconcepts of "Individual Programs"

   Related Concepts:
     1.  Parser Options
     2.  Parser Options that are Reserved Words
     3.  Adder and Concorder Options
     4.  ORBfile Program Options
     5.  Options on Rule Listing Programs
     6.  Resolver Options
     7.  Message Processor Options
     8.  Statistics Options

   Passages:
     9.  P9  Section 2.2  Options (13 lines)
    10.  P20 Section 3.1  Parser Options (27 lines)
```

Figure 7.6 Sample PERUSE Session (Page 2)

>FIRST CHOICE

```
   Choice 1.  Parser Options

   Related Concepts:
     1.  Setting Parser Options
     2.  Subconcepts of "Individual Options"
     3.  Subconcepts of "Files"

   Passages:
     4.  P9  Section 2.2  Options (13 lines)
     5.  P20 Section 3.1  Parser Options (25 lines)
```

>INTERACTING WITH log file

```
   Passages:
     1.  P29  L Option (1 line) in Section 3.1 Parser Options
     2.  P31  N Option (1 line) in Section 3.1 Parser Options
```

>LAST CHOICE

```
   Choice 2.  P31 N Option (1 line)
          in Section 3.1  Parser Options
          Page 6 Line 13
   Display?
```

>YES

```
##################################################################
#                                                                #
#     N (19)--do not write log file (see Section 4.2)            #
#                                                                #
##################################################################
```

>CROSS-REFERENCE

```
   P59 Section 4.2 The Log File (12 lines)
       Page 9 Line 11 through Page 9 line 22
   Display?
```

>YES

Figure 7.6 Sample PERUSE Session (Page 3)

```
#############################################################
#                                                           #
#     A log file, containing  most system messages and all  #
#                                                           #
# user input  read by UGIN (or UGINA6), will be catalogued  #
#                                                           #
# and saved for every run of LEXICO initiated  without the  #
#                                                           #
# N option whenever a master log file exists. A master log  #
#                                                           #
# will be created and initialized, but not saved, whenever  #
#                                                           #
# a run is initiated with the L option on and the N option  #
#                                                           #
# off, unless there is an existing master log.  The master  #
#                                                           #
# log file, called  5603*LOG, contains its length in words  #
#                                                           #
# in the  first location.  All following locations contain  #
#                                                           #
# names  of run logs in  two-word packets.  If no log  has  #
#                                                           #
# been catalogued, a  temporary log may be created on unit  #
#                                                           #
# 12 by setting option N equal to 0 after initialization.   #
#                                                           #
#############################################################
```

>CONCEPTS

```
   Log File
   Writing Files
   Naming Files
   Creating and Saving Files
   Mention of L Option on the Parser
   Mention of N Option on the Parser
```

>NEXT SECTION

```
   P60  Section 4.3  The Statistics File (3 lines)
        Page 10 Line 2 through Page 10 Line 4
   Display?
```

>NO

Figure 7.6 Sample PERUSE Session (Page 4)

>RETURN

```
   P59  Section 4.2  The Log File (12 lines)
```

>RETURN

```
   P31   N Option (1 line) in Section 3.1  Parser Options
```

>RETURN

```
   Choice 1.  Parser Options
```

Figure 7.6 Sample PERUSE Session (Page 5)

7.3.2 Display Conventions

7.3.2.1 Identifying Passages

Because the document to be inspected is also accessible off-line, every displayed passage must be identified in a way that simplifies transition between the interactive and off-line media. Page and line numbers provide some of the necessary identification. Section and chapter numbers and titles also help. Before displaying a passage, PERUSE identifies it with whatever names it has in the passage tree. Passages that are not explicitly marked in the original document are identified as a part of the smallest separately identified segment containing them. A final clue for locating a displayed passage within the printed version is provided by the passage numbers themselves. Because the nodes in the passage tree are numbered in symmetric order, the user can predict the relative position of two passages. P12, for instance, must either precede or include P29. On the third page of Figure 7.6, since P59 consists of exactly Section 4.2, it is listed as

P59 Section 4.2 The Log File (12 lines)
Page 9 Line 11 through Page 9 Line 22

In contrast, P31 is not a separate segment in the text. Therefore, it is described as

P31 N Option (1 line)
in Section 3.1 Parser Options
Page 6 Line 13

Since different conventions are used to label segments of written documentation, some care is necessary in providing a general implementation. In order to allow the peruser to access material by the names used in a particular text, the expert must inform ENCODE of the naming and numbering conventions used within it. "Chapter" and "section" are not the only words used to identify text segments. Segments from LEXICO's user documentation, for example, need to be identified by guide number as well. Neither titles nor section numbers can be assumed to be unique. Several chapters in one document may have a "Section 2"; the first display in Figure 7.6 shows that Section 2.2 and Section 3 of the LEXICO Maintenance Guide are both entitled "Options".

In some of the commands described below, the peruser may specify a particular passage. In such cases, it is assumed that the peruser may enter any relevant page, section, or passage number. The following are all valid possibilites:

section 2.3
chapter 2
chapter 2, section 3
index
page 4-19
appendix A
P39

7.3.2.2 Preventing Lengthy Displays

Without forcing a user to repeatedly respond to an "are-you-sure-you-want-to-see-this" prompt, PERUSE must protect the user from being inundated with large amounts of output. The definition of "large" is elusive in this context: its meaning is dependent on screen width, transmission speed, the user's mood, and the total document length. A sophisticated algorithm could employ terminal characteristics, user profiles, and suggestions from the expert who encoded the document. To minimize the number of lines shown, whenever a list contains three or more descendants of a single concept, the ancestral concept is displayed instead. Thus, at the beginning of Figure 7.6, the entry is

4. Subconcepts of "Individual Programs"

instead of a list of all the programs whose options are described in the text.

Redundancy is eliminated in lists of passages. If the passage-dependent network indicates that both a passage and one of its subpassages are pertinent to some concept, there is no need to list the subpassages. Similarly, instead of listing all the subpassages of a passage, only the parent passage is identified.

As further protection from accidental requests for lengthy and time-consuming displays, PERUSE indicates the amount of output to be expected. The identification of each passage includes a line count. The displayed number reflects the space required to list the passage at the terminal, rather than its volume in the original document.

7.3.2.3 Connecting Phrases and Section Headings

Some passages may consist solely of connecting phrases such as "on the other hand," or "This situation also exists in other contexts." There is no point in displaying these passages unless both the preceding and succeeding segments are listed as well. The passage numbers of connecting phrases need never be shown. The following dialogue would be slightly ridiculous:

>P17

P17 Some Section in Some Manual (24 lines)
1. P18 First Point (10 lines)
2. P19 Connecting Phrase (1 line)
3. P20 Second Point (13 lines)

Instead PERUSE would respond as follows:

>P17

P17 Some Section in Some Manual (24 lines)
1. P18 First Point (10 lines)
2. P19 Second Point (13 lines)

If the user first viewed "First Point" and then "Second Point", the connecting phrase would automatically be displayed at the appropriate time.

In general, section headings can be treated as connecting phrases. Since the section heading is shown when PERUSE asks if the segment should be displayed, it is not necessary to repeat the heading when the passage is shown. If the peruser continues to read succeeding material, any additional titles encountered are displayed.

7.3.2.4 Other Conventions

In an actual implementation, conventions must be established for entering reserved words as data items, for entering a long command over several lines, and for entering several commands on a single line. Upper/lower case distinctions are usually ignored in PERUSE commands. Occasionally, the meaning of a keyword depends on such

distinctions. In the LEXICO Maintenance Guide, for example, "The Parser" refers to a program; "PARSER" is a file containing the source code for that program. The expert must declare similar cases to ENCODE when establishing the lexicon. In ambiguous cases, or when receiving input from an upper-case only terminal, PERUSE prompts the user for the intended meaning.

PERUSE should provide a comment facility so the peruser can annotate a session. Finally, a mechanism should exist for posting messages to the expert who maintains a strep or to the writer who updates a document.

7.3.3 PERUSE Commands

7.3.3.1 Command Summary

The PERUSE commands are listed below. Brackets enclose optional phrases; braces delimit alternatives. Keywords are in capital letters; peruser-specified values in lower-case.

ABOUT expression
OCCURRING WITH expression
INTERACTING WITH expression
EXCEPT expression
OR expression

```
{FIRST  } {CHOICE  }
{LAST   } {SECTION }
{NEXT   } {LEAF    }
{PREV   }

{CHOICE  } {+} [ n ]
{SECTION } {-}
{LEAF    }

PASSAGE passage

CONCEPTS

{SUB  } {CONCEPTS  } [ FOR n LEVELS ]
{SUPER} {PASSAGES  }

CROSS-REFERENCE
NOTE
FOOTNOTE

RETURN {n   }
       {name}
CHECKPOINT name

STATUS

{COLUMN} head [ = value1 [ TO value2 ] ] OF table
{LINE  }      [ FOR m ]
{COLUMN} HEADINGS [ OF table ]
{LINE  }

{UP   } n  COLUMNS  [ FOR m ]
{DOWN }    LINES
{LEFT }
{RIGHT}
```

Figure 7.7 PERUSE Commands

7.3.3.2 ABOUT and Its Variations

The ABOUT command described in this subsection requires the most explanation. The command's syntax is

ABOUT expression

where expression is formed from lexicon entries and the connectives, OCCURRING WITH, INTERACTING WITH, OR, and EXCEPT. As explained below, OCCURING WITH and INTERACTING WITH may be interpreted as two forms of "AND". The keywords in the expression refer to names or functions in either the passage-dependent network or the passage tree. OCCURRING WITH, INTERACTINB WITH, and EXCEPT have precedence over OR, but parentheses may be used to depart from this convention.

The ABOUT command causes PERUSE to display a list of all passages pertinent to the indicated concepts along with any additional concepts that can be used to distinguish among these passages. As a rule, the identified passages have the selected concepts as the topic or a co-topic. However, if the peruser wishes to see sections where the selected concepts are mentioned in some other context, he may include "mention" as one of the concepts in the boolean expression.

When the command is entered, PERUSE searches the lexicon for the concepts used in the expression. Assume momentarily that the lexicon entries all point to nodes in

the passage-dependent network. PERUSE follows the paths emanating from these nodes and builds a set of passages referenced at the ends of these paths according to the specified connectives. When two subexpressions are joined by INTERACTING WITH, the intersection of the paths determined by the subexpressions is used; paths joined by a co-occurrence node are treated as non-intersecting. When two subexpressions are joined by OCCURRING WITH, the intersection of the sets of references determined by the subexpressions is used. When two subexpressions are joined by OR, the union of the sets they determine is formed. Finally, all references determined by the second of two subexpressions joined by EXCEPT are discarded from those determined by the first.

The result of the ABOUT command is a two-part display. First, PERUSE lists identifiers of nodes encountered along the examined paths, except 1) those nodes used by the peruser in the expression and 2) those nodes discarded by use of EXCEPT. If an encountered node has no identifiers, the identifiers of its closest identified ancestors are displayed instead. The second part of the ABOUT output is a list of the passages in the final set.

For example, suppose a peruser wishes to ask the question

> Which programs other than the Parser have an X Option?

He can enter the request as

> ABOUT program INTERACTING WITH x option EXCEPT the parser

The appropriate portion of the passage-dependent network for the LEXICO Maintenance Guide is shown below.

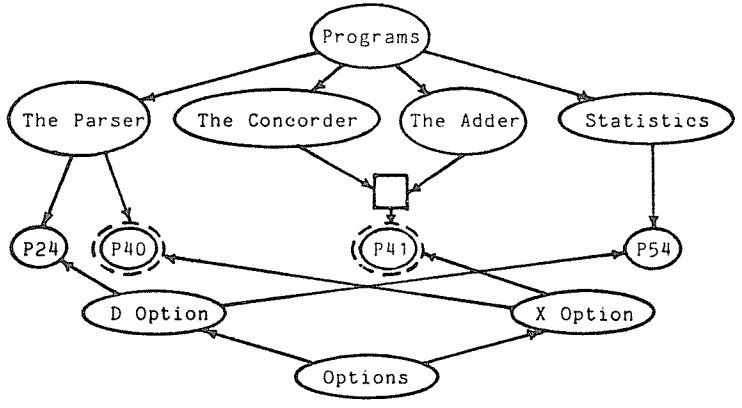

Figure 7.8
The Relevant Portion of the Passage-Dependent Network

The dotted circles indicate nodes on the intersection of paths from "Programs" and "X Option". The pointer to P40 is discarded because it is descended from "The Parser". The nodes named "The Concorder" and "The Adder" are encountered on the traversed paths, so their identifiers are displayed.

The output from this command is shown in Figure 7.9. Only one passage is found, so PERUSE asks the user if the passage should be displayed.

```
Related Concepts:
  1.  The Concorder
  2.  The Adder

Passages:
  3.  P41  3.2  Adder and Concorder Options (5 lines)
               Page 6 Line 2 through Page 6 Line 33
Display?
```

Figure 7.9 Result of the ABOUT Command

Because this portion of the passage-dependent network does not contain multiple references to a single passage, the same results would be produced by the command

ABOUT program OCCURING WITH x option EXCEPT the parser

If, however, there is more than one reference to a single passage, the two connectives can produce different results. Suppose passage P5 in a revision of the LEXICO Maintenance Guide were to read as follows:

> This document describes supporting programs (e.g., The Resolver and The Message Processor) and auxiliary files.

and that the passage-dependent network contains this subgraph

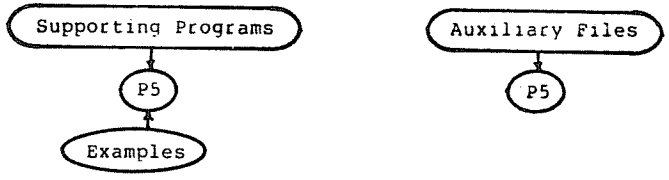

Figure 7.10 Subgraph with Two References to P5

If the peruser enters

ABOUT example INTERACTING WITH auxiliary files

the null set results; paths descended from "example" and "auxiliary file" do not cross. However,

ABOUT example OCCURRING WITH auxiliary files

yields P5, since P5 is referenced on paths descended from each of these concepts.

The distinction between these connectives is related to that between category and co-occurrence nodes. INTERACTING WITH yields passages pertinent to a combination of the specified ideas (in this case, "example of auxiliary files"); while OCCURRING WITH lists passages where both concepts happen to appear. As long as valid lexicon entries are requested, PERUSE can never give a null response to an OCCURRING WITH expression. However, the only passage where two concepts co-occur may be the entire text; the peruser will be more interested in the smallest passages where the

concepts co-occur. When responding to the ABOUT command, PERUSE lists only the parent passage if the results of an INTERACTING WITH expression include all its children. Because of the information loss that would result, this simplification is not performed for an OCCURRING WITH expression. Perusers are likely to use INTERACTING WITH more often. OCCURRING WITH can be helpful in locating passages containing concepts interactions not encoded by the expert.

Entries in the lexicon may point to the passage tree as well as the passage-dependent network. This possibility is useful in two situations. First, it permits the peruser to use the ABOUT command to locate a passage by title alone. Second, it saves the expert the work of adding concepts to the passage-dependent network for each topic discussed in only a single portion of the text. PERUSE processes expressions that refer directly to the passage tree as though an extra category node existed in the passage-dependent network for each passage in the passage tree. An arc connects the assumed node for a passage with every terminal node in the passage-dependent network referring to that passage or to one of its subpassages. If no terminal node refers to a passage, one is generated for this purpose. The assumed node has no identifiers. The

lexicon entry for any passage identifier points to the assumed node for the passage.

For example, the ASCII Fortran Supplement contains a section entitled "Cost Warnings to FTN Users". One of the subsections of this passage is called "Direct Access I/O". Although the concept "cost" is not encoded in the passage-dependent network, PERUSE would respond to the request

```
ABOUT cost AND direct access I/O
```

with

```
P69  Direct Access I/O (7 lines)
     Page 13 Line 6 through Page 13 Line 7
Display?
```

Lexicon entries may refer either to names or to functions. In some circumstances, some ambiguity may result. If a programming language has a DEFINE statement, the request

```
ABOUT define INTERACTING WITH parameter
```

cannot be uniquely interpreted. Does the peruser want a definition of the word "parameter" or is he asking about the parameters of the DEFINE statement? An actual implementation must provide a simple means of disambiguating such requests.

The commands

INTERACTING WITH expression
OCCURRING WITH expression
EXCEPT expression
OR expression

qualify the result of a preceding ABOUT command. Expression is an expression of keywords similar to that in an ABOUT command. The result of the sequence

ABOUT expression1
INTERACTING WITH expression2
EXCEPT expression3

is equivalent to the single command

ABOUT expression1 INTERACTING WITH
expression2 EXCEPT expression3

However, each ABOUT command begins a new sequence that is independent of all preceding commands.

Selection of a "related concepts" choice after an ABOUT command is equivalent to the appropriate RESTRICT command. In the first exchange from Figure 7.6, the entries

2

and

RESTRICT setting parser options

would produce identical results.

7.3.3.3 The CHOICE, SECTION, LEAF, and PASSAGE Commands

At any choice point, the peruser may enter the integer number of a selected option. Alternatively, a CHOICE

command may be entered to select the first or last option, or to make the decision relative to a previous choice from the list. Figure 7.11 uses the ASCII Fortran Supplement to illustrate some of the possibilities. (Note that since only one passage is located by the original ABOUT command, PERUSE immediately identifies its subpassages.)

```
>ABOUT checkout INTERACTING WITH commands

   Related Passages:
     P44 in P40 CHECKOUT and FTNR (47 lines)
       1.  P45 Call subprogram[(arg1,...,argn)]
           (7 lines)
       2.  P46 DUMP[,opt] [var] [/unit] (8 lines)
       3.  P47 Go [nL] (5 lines)
       4.  P48 BREAK, CLEAR, SET, SETBP (7 lines)
       5.  P49 SETBP[,opt] var[/unit] (15 lines)

>LAST CHOICE

   P49  SETBP[,opt] var[/unit] (15 lines)
        Page 10 Line 2 through Page 10 Line 16
   Display?

>NO

>CHOICE-

   P48  BREAK, CLEAR, SET, SETBP (7 lines)
        Page 9 Line 31 through Page 9 Line 37
   Display?

>NO

>3

   P47  Go [nL] (5 lines)
        Page 9 Line 26 through Page 9 Line 29
   Display?
```

Figure 7.11 Sample Dialogue Using CHOICE Commands

The SECTION commands allow the user to select various subpassages of a current passage. When any of the PERUSE commands so far discussed select a non-leaf passage, the result is a choice point listing the subpassages of the

selected passage. This convention protects the peruser who enters

CHAPTER 2

from receiving a twenty-page display. Nevertheless, a peruser who really wishes to inspect a long passage may find it tedious to step through the tree structure. The LEAF commands display text segments associated with nodes along the portion of the frontier of the passage tree that descends from the specified passage. The syntax of the SECTION and LEAF commands parallel that of the CHOICE commands.

It is to be expected that the CHOICE, SECTION, and LEAF + and - commands will be used most often with the default value of 1 for the parameter n. There are two situations when it is useful to specify another value. One occurs when a segment begins with the warning that some readers may wish to skip a specified number of sections. The other situation occurs when the peruser who has read several consecutive passages wishes to reread one of the earlier ones (which may have disappeared from the screen) and then continue.

The peruser who knows the location of desired material need not bother with an ABOUT command and selection of one of the resulting choices. A segment may be requested by

passage number, section number or page number with the command

PASSAGE passage

If a page is named, PERUSE displays the leaf passage containing the first line on the specified page. With the strep shown in Appendix D for the LEXICO Maintenance Guide, the following commands all produce the same result:

```
PASSAGE P16
PASSAGE section 2.9
PASSAGE page 5
```

7.3.3.4 Commands for Browsing Through the Strep

The peruser may inspect portions of the passage-dependent network and passage tree. The SUB and SUPER commands cause display of n generations of ancestors of specified nodes; n is either a positive integer or the word ALL. The CONCEPTS command causes PERUSE to list the modifiers (other than "Topic", "Co-topic", "Mention", or descendants of "Cross-Reference") of all nodes in the passage-dependent network that point to a current passage.

The CROSS-REFERENCE command transfers to a section identified in an internal cross-reference within the current passage. NOTE and FOOTNOTE are special cases of this

command. If only one cross-reference occurs, PERUSE asks the user whether the referenced section should be displayed. If the original passage contains more than one cross-reference, PERUSE lists the referenced sections and asks the peruser to choose among them. Of course, the peruser is only able to access cross-references that have been encoded in the strep by the expert. Implicit cross-references may sometimes be available, however.

7.3.3.5 RETURN, CHECKPOINT, and STATUS

PERUSE maintains a stack describing the program's status as each command is processed. The one-word RETURN command is used to return PERUSE to a previous state. When entered after any selection from a choice point, the RETURN command causes PERUSE to resume at that choice point. When entered after CROSS-REFERENCE, this command causes PERUSE to return to the referencing passage. RETURN can also undo the effect of a RESTRICT, REMOVE, or ADD command. After SECTION+1, RETURN returns to the preceding section. The results of RETURN are not always defined; RETURN makes no sense after an ABOUT or PASSAGE command. The command

RETURN n

where n is an integer, causes the system to resume at the same point as n successive RETURN commands.

Of course, after a few levels, it becomes annoying to count the number of RETURN's needed. At any time, the peruser may enter

CHECKPOINT name

where name is an alphanumeric identifier containing at least one letter. Then, any number of commands later (including ABOUT or PASSAGE commands), the peruser may enter

RETURN name

to cause PERUSE to resume at the state where the CHECKPOINT command was entered. Because a checkpoint may be popped from the stack used by the RETURN n command, PERUSE maintains a separate list of checkpoints.

After a RETURN command, PERUSE displays a summary of the resulting state. For example, after a RETURN to a particular passage, PERUSE displays its passage number, section number, and title and the page and line numbers it occupies in the text; the text segment itself is not displayed. After a RETURN to an ABOUT command, PERUSE displays the expression used to define it; the resulting choices are not shown again.

The STATUS command is used to obtain more complete information after a RETURN -- a new prompt to display a

portion of text or the list of choices at a choice point. The STATUS command may also be used after a sequence of OCCURRING WITH, INTERACTING WITH, EXCEPT, and OR commands to obtain a list of the complete expression defining the current state.

7.3.3.6 Table of Contents, Index, and Other Tables

Tables of contents, indices, command summaries, and lists of character sets, reserved words, or rates for different computing services constitute a special class of text components called tables. These structures often appear in appendices as well as within the body of a text. The LEXICO Maintenance Guide, for example, contains tables in the lists of options given in Section 3 and in the list of packet types in Section 5.2.

Although tables are not segments of running text, the division of a table into distinct passages is needed to select portions of the table by keyword. For example, the result of

ABOUT the parser INTERACTING WITH x option

is P40:

X (29)--display undefined packets

A peruser must be able to inspect any portion of a table. The necessary information can be encoded in a strep if the table as a whole is delimited as a separate passage serving the function, "table". The subpassages of the table correspond to lines across it. In particular, the first subpassage in many tables serves the function, "column headings". Each line in the table is subdivided into its various fields. The fields are identified by line and column headings and numbers.

PERUSE has several commands for inspecting the first table in any specified passage or the current passage. The peruser may print any number of lines or columns and he may search for values in a specified field. Each field may be identified by line or column number or title.

The TABLE commands are also useful for searching through a manual's index. The peruser may easily inpsect each of the pages listed in an index entry with a CROSS-REFERENCE command. An example from a hypothetical manual is shown in Figure 7.12 below.


```
>COLUMN 1  logical expression OF index

   logical expression.......63,75-78,112

>CROSS-REFERENCE

   1.  P58   Section 2.3  Logical Variables (20 lines)
   2.  P319  Section 6.4  Logical Expressions (67 lines)
   3.  P372  Section 7.1  IF Statements (28 lines)

>2

   Choice 2.  P319 Section 6.4
              Page 75 Line 19 through Page 78 Line 8
   Display?
```

Figure 7.12 Consulting the Index

7.3.4 Final Remarks

The commands listed in the previous section allow the peruser to locate any needed material easily. Although preceding chapters have dealt with the information to be encoded in a strep, little has been said of the internal representation of the data structure. The design of the file formats and other conventions is a nontrivial project. However, several well-known techniques can be applied. The lexicon, for example, would presumably be stored as a random-access file from which pointers to the

passage-dependent network are retrieved using a hash-coding scheme. Some internal details are largely dependent on the operating system under which THUMB is implemented. Because of this dependence and because similar problems are solved in the development of every computer system using large semantic nets, this aspect of the implementation of PERUSE is not discussed here. Once the internal representation of a strep is designed, the implementation of PERUSE is a substantial but straightforward programming task.

PERUSE should record some information about its own use. The OLDS documentation system [53] used at New Mexico State University operates on the philosophy that writeups accessed most frequently are most important and therefore should be most frequently revised. That system records the number of times its users refer to each section. PERUSE can provide experts and writers with similar data. It can also record the number of times lexicon entries are used.

The program should keep track of requests it is unable to answer -- keywords that do not appear in the lexicon and expressions in ABOUT commands that yield no passages. Such data reflect spelling errors on the part of the perusers; they also suggest revisions to the lexicon, passage-dependent network, and the text itself.

7.4 ENCODE

7.4.1 Overview

The availability of streps to PERUSE, and their effective design, depend on the ease with which they may be entered and maintained by the expert. Although the bulk of the work must be done by a human reader who understands the material, ENCODE is designed to remove as much drudgery from the task as possible. It is easier for an expert to encode a strep than to write a special on-line version of a manual. In the following pages, ENCODE is first described in relation to existing documents; its value as a writing tool is mentioned at the end of the chapter.

THUMB's second subsystem has several components. Once the expert establishes communication with ENCODE at an interactive terminal, he identifies the particular subprocess he wishes to perform. When the requested component involves tasks that can be processed quickly, or when it is convenient for ENCODE to prompt the expert for pertinent information, the process is performed interactively. When the requested task is costly because it requires scanning the entire text or printing large listings, ENCODE initiates a batch run that performs the

desired operation at a later time. Because there is one controlling interactive program, the expert can easily switch from one task to another. In addition, he need not memorize the formats of the various control cards needed to run the batch components of ENCODE -- these details are handled by the interactive component.

The feasibility of a mixed batch and interactive system accessed with a consistent means of communication is exemplified by LEXICO [73, 73, 75, 76]. LEXICO uses another technique that is borrowed by ENCODE. A batch program produces a first approximation to an analysis that is not well-enough defined for complete computerization. Any resulting errors are corrected interactively. In ENCODE, this estimate consists of tentative processing of a document's index and table of contents as well as the attempt to locate cross-references, examples, and other selected concepts automatically.

The major components of ENCODE are

ENTERTEXT: a batch program that scans a machine-readable copy of a document, augmented by various commands that describe the format of the text and the formation of the passage tree. ENTERTEXT enters the passage tree and text segments into the strep. It makes tentative entries in the lexicon and passage-dependent network. It produces several printed listings.

NEWCONCEPTS: an interactive program that prompts the expert for instances of the concepts common to this kind of document and for passage references to be associated with the entered concepts. NEWCONCEPTS enters information into the lexicon and the passage-dependent network.

CHECK: an interactive process that cycles through the associations made by ENTERTEXT and DOCSCAN, allowing the expert to verify or correct each one.

OFFLINELIST: a batch routine that produces an off-line listing of any component of the strep: the lexicon, passage-dependent network, passage tree, or text segments.

DOCSCAN: a batch routine that is optionally initiated by NEWCONCEPTS. DOCSCAN searches through the text segments for keywords entered into the lexicon by NEWCONCEPTS. As keywords are encountered, tentative passage references are added to the passage-dependent network. These references may later be verified through CHECK.

EDITSTREP: an interactive component that allows the expert to inspect, insert, delete, or modify any portion of the strep.

The operation of ENCODE is diagrammed below.

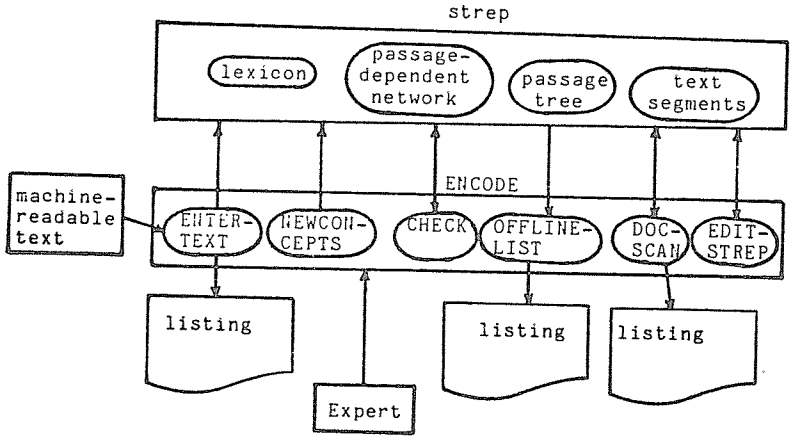

Figure 7.13 ENCODE

The ENCODE processes need not be executed in any given order. Although ENTERTEXT will usually be run only once, the other components can be used repeatedly during the process of encoding a single strep. Typically, ENTERTEXT and NEWCONCEPTS will be run before the others. If NEWCONCEPTS is run first, DOCSCAN and ENTERTEXT can be executed simultaneously. Off-line listings can be obtained whenever they are needed. CHECK can be used after each run of ENTERTEXT or NEWCONCEPTS. Some experts may not use

NEWCONCEPTS or CHECK; they may prefer to enter the same data through EDITSTREP.

The design of the controlling interactive program makes it easy for the expert to alternate among CHECK, NEWCONCEPTS, and EDITSTREP. In addition, he may at any time test any portion of the strep by observing PERUSE's performance on the data.

The individual ENCODE processes are described below. Because ENCODE has so many more commands than PERUSE, and because the functions to be performed are more easily understood, the ENCODE subsystem is discussed here in less detail than was given to PERUSE in Section 7.3.

7.4.2 ENTERTEXT--Inputting the Text

Initial generation of the passage tree is done in batch mode using a program called ENTERTEXT. The expert supplies an input file that contains the text of the document, a description of its format, and a description of its segmentation. There are two types of records in this file: lines of text and ENTERTEXT commands. Some of the latter pertain to the appearance of the text. The PAGE command

indicates the start of a new page in the printed text. Since page numbers throughout a text are not always continuous, the page number, page, must be specified. Thus, page numbers of prefatory material (i, ii, iii, etc.), of inserted pages (2a, 2b, etc.), and of different chapters (2-1, 2-2, 3-1, 3-2, etc.) can be entered. Of course, conventions for automating regular sequences of page numbers could be established.

The SINGLE and DOUBLE SPACE commands and the SKIP command refer to the appearance of blank lines in the text. Each paragraph must be preceded by either a FIXED or a VARIABLE command. FIXED indicates that the succeeding material must remain in its original position on a line of text. Tables and sample programs, for example, have this property. VARIABLE indicates that horizontal spacing is not significant in the succeeding paragraph. When a paragraph is preceded by the VARIABLE command, PERUSE displays the passage starting at the left margin of the screen. It fills a line on the terminal with as many words from the printed text as room allows, and in this manner continues to print successive lines of the paragraph. Of course, a displayed passage may contain more than one paragraph.

Since the purpose of this chapter is to discuss a practical application of streps, every input problem has not

been covered. The omitted issues include subscripts, superscripts, italicization, underlining, special characters, and footnotes. When portions from two lines in a printed manual are concatenated, PERUSE must know whether to retain or discard a line-final hyphen. A more substantive area is the inclusion of nonverbal figures. If PERUSE is to be used from a graphics terminal, the input to INITSTREP can contain digitizations of illustrations and commands describing how this material should be displayed. On a terminal without plotting capabilities, figures must either be omitted or described as accurately as possible with the available character set.

Along with the text and its formatting conventions, the input to ENTERTEXT shows the formation of the passage tree and the names and functions assigned to its nodes. A portion of the LEXICO Maintenance Guide, as prepared for ENTERTEXT, is shown in Figure 7.14. Parentheses delimit passages. The two parentheses in this sample indicate that Section 2 is a separate passage and that its first subpassage, Section 2.1, is a leaf. The SECTION and TITLE commands identify section numbers and section headings.

```
PAGE 2
(
SECTION Section 2
TITLE Command Language
(
SECTION Section 2.1
TITLE ROUTE
FIXED
     The commands
SKIP 1
SINGLE SPACE
       ROUTE r ;
       ROUTE r n ;
       ROUTE r m - n ;
       ROUTE r charst ;
DOUBLE SPACE
VARIABLE
 may be used to transfer to a route r in QUEENB (after
 setting NUM, NUMM, and NUMN, or SCHSEQ and IS). These
 statements may appear in any block. They have two
                          .
                          .
                          .
```

Figure 7.14 Sample of ENTERTEXT Input

While the names assigned with the SECTION and TITLE commands depend on the document being encoded, identifiers on the FUNCTION command are known in advance by ENTERTEXT. These items are listed in Figures 6.1 and 6.2. Among the functions that may be specified are "table" and "table heading". The FIELD command identifies columns in a table. The example shown below encodes the table of contents from the ASCII Fortran Supplement. The TITLE command identifies the name of the passage within the document. The title is capitalized and underlined here because it is capitalized

and underlined in the manual. The FUNCTION command identifies the purpose of the table.

```
TITLE TABLE OF CONTENTS
FUNCTION table of contents
FIELD 2-44,45-46
 FTN Compiler Option Changes . . . . . .2
 Collection of FTN Programs. . . . . .2
 Interactive Postmortem Dump . . . . . .3
 FTN Walkback Facility . . . . . .3
                          .
                          .
                          .
```

Figure 7.15 Entering a Table of Contents

7.4.3 Processing the Input File; CHECKing the Results

As ENTERTEXT scans the input file, it numbers the passages and creates the passage tree. The program updates the lexicon to include entries for the page numbers and section headings encountered. It counts the number of non-blank lines on a page and records beginning and ending page and line numbers for each passage. The printed output from ENTERTEXT has three parts. The first part shows the structure of the passage tree in outline form and the second

shows the text segment associated with each leaf passage. These listings are illustrated in Appendices A through D of this thesis. The third part of ENTERTEXT's output shows the lexicon entries made by the program.

ENTERTEXT looks for the expressions, "example", "for instance", and "e.g.", and marks passages that probably contain examples. It also searches for words that suggest explicit cross-references: mention of section or page numbers, "see", "following", "earlier", "above", and "below". When a phrase such as "described in Section 3.7" is found, ENTERTEXT creates a cross-reference from the current passage to Section 3.7. However, when a phrase such as "described below" is located, the program is unable to identify the referenced passage. In this case, it records the location of the cross-reference, so that the CHECK program can prompt the expert for the missing information.

When ENTERTEXT encounters a LABEL command, it processes the succeeding passage accordingly. While scanning a manual's table of contents, the program translates page numbers of named sections into passage references. ENTERTEXT enters each item in the index into the lexicon. It translates page numbers in index entries into passage numbers by assuming that the first passage on the specified page or range of pages is the one intended. These assumed

cross-references are tentatively entered into the passage-dependent network.

As ENTERTEXT prints the text segments associated with each leaf passage, it notes in the margin any references it has created in the passage-dependent network pointing to that passage. The expert may inspect these marginal notes off-line and make any necessary corrections at a later time. If he chooses to enter the corrections with the CHECK routine, that program steps through a specified segment of text, displaying each generated item in the passage-dependent network that refers to the passage. As each item is shown, the expert may leave it as is, delete it, or modify it. A typical change is to sharpen a reference from a large separately-titled passage (e.g., Chapter 2) to a specific subpassage. If a manual has an index, the expert can correct any erroneous page references generated by ENTERTEXT. CHECK also prompts the expert for the information needed to complete vague cross-references (e.g., "see below").

7.4.4 NEWCONCEPTS

The NEWCONCEPTS program prompts the expert for names to be classified under various functions. Using the functions listed in Figures 6.1 and 6.2 -- "programs", "parameters", "options", "commands", "syntax", and so on, it asks the expert to enter names of concepts in selected categories. It also prompts for passages pertinent to the entered concepts. The program uses knowledge about the relationships among the entities usually discussed in programming manuals. If the expert enters the name of a subroutine, the program prompts for a list of its parameters. It asks the expert to identify the passages describing the operation of the routine, its calling sequence, and each parameter. Similarly, if the expert enters a command name, NEWCONCEPTS prompts for the location of descriptions of its syntax and of its semantics.

As the expert supplies each name, NEWCONCEPTS enters it into the lexicon. The program creates a node for the concept in the passage-dependent network, making the new node a descendant of the function concept. For example, if the expert declares a subroutine named "SORT", NEWCONCEPTS adds this node as a descendant of "Subroutine". In addition, as each passage reference is supplied, NEWCONCEPTS

enters appropriate pointers in the passage-dependent network.

Figure 7.16 shows a dialogue between NEWCONCEPTS and the expert encoding the ASCII Fortran Supplement. The exchange consists of a series of questions asked by the program and the responses entered by the expert. Any time the expert is unsure of the response expected, he may enter "HELP" to request an explanation. Figure 7.17 shows the resulting portion of the passage-dependent network.

```
 Function?
>HELP
 Enter one of the following:
   programs
   parameters
   options
   commands
   data structures
 (For other possible functions, enter HELP again)

>COMMANDS

 Command?

>walkback

 Command: Walkback
   Syntax described?
>P20

   Semantics described?
>P23

   Examples?
>P24

   Other references?
>YES
   concept?
>occurrences
   where?
>P17, P19

   Other references?
>NO
```

Figure 7.16 A Session with NEWCONCEPTS

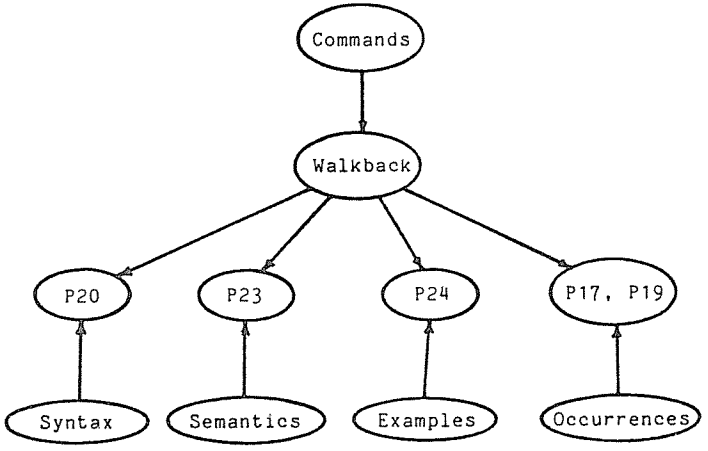

Figure 7.17
Passage-Dependent Network Entries Generated by NEWCONCEPTS

NEWCONCEPTS is one of the few components of THUMB that is specifically oriented to programming manuals. A possibility for future research is the design of a "meta-NEWCONCEPTS" program. Such a system would prompt for the functions to be used by ENTERTEXT and NEWCONCEPTS. The user would also supply semantic rules for interpreting the functions and the expected relationships among concepts in the entered categories. This program would make THUMB available to readers of different types of documents.

7.4.5 DOCSCAN

Figure 7.17 does not indicate every passage in the ASCII Fortran Supplement that is pertinent to the concept, "walkback". "Walkback" is mentioned in the table of contents and in the discussion of the compiler F option in P10. The expert does not have to encode the table of contents entry; this item is located by ENTERTEXT when that program processes the table of contents. The expert could have entered the reference to P10 through NEWCONCEPTS. However, in this case, he has chosen to let this reference be located by another program, DOCSCAN.

DOCSCAN searches through the text for occurrences of keywords stored in the lexicon by NEWCONCEPTS. In the example from the ASCII Fortran Supplement, once "walkback" is entered into the lexicon by NEWCONCEPTS, DOCSCAN can find the reference to this term in P10. Since references to P5 (the table of contents), P20, P23, P24, P17, and P19 were encoded by NEWCONCEPTS and ENTERTEXT, DOCSCAN ignores occurrences of the word in these passages.

The output from DOCSCAN is similar to the text-segment listing produced by ENTERTEXT. DOCSCAN also prints marginal notes showing the passage references it has generated.

After studying the DOCSCAN listing, the expert may use the CHECK routine to validate the data encoded by DOCSCAN.

7.4.6 EDITSTREP

The ENCODE programs described thus far are not sufficient to build an accurate strep. A manual may not have a table of contents or an index for ENTERTEXT to process. Even if it has both, the printed index is unlikely to show all the different groupings of concepts that can be useful in the passage-dependent network. The expert must have the opportunity to add keywords and concepts without relating them to the general functions known to NEWCONCEPTS. In addition, he must be able to modify all portions of the data structure.

The EDITSTREP program allows the expert to inspect, insert, delete, or modify any portion of a strep. Of all the programs that compose ENCODE, the expert will probably use EDITSTREP most often. To process revisions to a document as well as corrections to the original input file, EDITSTREP must have all the capabilities of a general-purpose text editor. In addition, it must be able to manipulate the arcs and nodes in the passage-dependent

network and passage tree as well as the pointers that link the pieces of a strep together.

The passage tree can be changed by combining sibling passages into a single node or by splitting a node into subpassages. When a passage is combined with a neighboring one, EDITSTREP changes references to either passage in the passage-dependent network so that they refer to the combined passage. When a passage is subdivided, EDITSTREP asks the expert whether references to the original passage should be left as is or changed to refer to one of the new subpassages. Names and functions in the passage tree can be changed, inserted or deleted; corresponding updates are made in the lexicon. When the expert revises a text segment, appropriate changes are automatically made to the page numbers and line counts stored with the passage tree. At the end of a session with EDITSTREP, consecutive passage numbers are assigned to the nodes in the passage tree; passage references in the passage-dependent network are updated to reflect the new numbers.

EDITSTREP has other commands that allow the expert to modify lexicon entries: he can specify new synonyms, change pointers to the passage-dependent network, and so on. In the passage-dependent network, the expert can inspect the ancestors or descendants of any concept. He can add or

delete nodes or arcs; he can add, delete, or change node names or functions.

7.4.7 ENCODE as a Writing Tool

The use of THUMB presumes a machine-readable copy of the printed text. A significant portion of the expense of encoding a document is often due to preparation of the original input. However, as word-processing systems are used to produce an increasing amount of program documentation, the problem of generating machine-readable input is diminishing. In any case, it is hoped that the benefits provided by THUMB to the peruser far outweigh any development cost to the expert.

In a situation where production of an off-line text is partially automated, it is unnecessary to use a document-preparation system as a preprocessor for ENCODE. The former program uses some of the information that must be encoded into the input file for ENTERTEXT -- the word processing system must be able to underline, to use subscripts, to compute page numbers, to count the number of lines per page, to single or double space, and to recognize paragraphs to be printed in fixed or variable formats. The

expert should not be required to duplicate these specifications for different programs.

When the expert who encodes a document happens to be its author, time can be saved if ENCODE is implemented as an extension of a document-preparation system. By interspersing ENTERTEXT and formatting commands with textual material, the same input file can be used to produce both on-line and off-line documentation. If the format of the internal file on which EDITSTREP maintains the text segments is compatible with the text-preparation program, a revision entered through EDITSTREP can be cycled through the text-formatting program to produce the off-line revision. In this way, neither the on-line nor the off-line document will ever be more up-to-date than the other version.

The merging of ENCODE with a word-processing system has other advantages. If the strep is completed before a final draft is printed, the passage-dependent network can be used to produce a thorough index automatically; the passage tree can generate a table of contents. Appendices listing all the commands or all the reserved words in a programming language can also be generated automatically from the passage-dependent network. The strep can be used to organize partially-written material. An author can use

EDITSTREP to rearrange, cross-reference, and expand material.

Some printed manuals describe commands or routines in alphabetical order. ENCODE can sort text segments that are generated in a more natural order. Furthermore, it can retain the original order so that perusers can access the material by either arrangement. Freedom from linear ordering is one aspect of the "hypertexts" described by Nelson [49]. For documents restricted to interactive use, no fixed sequence of passages is needed; all access can be made through the passage-dependent network.

8. Other Applications

8.1 Introduction

The first criterion listed in Chapter 3 for measuring the success of the strep is that of practicality:

> The resulting description should be economically usable in several practical applications.

In the previous chapter, an application to information retrieval was thoroughly described. Also, possibilities for assisting writers were mentioned. This chapter presents other uses for the strep.

8.2 Automatic Generation of Text

The writing tools mentioned in Chapter 7 presuppose that an author will provide both the content and the actual wording of each passage. Algorithms for generating stories have so far produced very condensed plot summaries rather than natural-sounding texts. Meehan [45] manually

paraphrased the output of his text-generating program before reporting the results in his thesis. Prince [55] points out that the sequence of events produced by his transformational grammar can be embodied in media such as plays, films, or drawings as well as spoken or written language. Repetitious sentence structure and lack of detail cause the stories generated by Klein's "meta-symbolic simulation system" [38, 39, 40] to seem like a list of sentences rather than a coherent text.

The output of these algorithms can be viewed as structural descriptions rather than complete texts. Even as structural representations, they are rather sparse. Only the events themselves are included. Point of view, emphasis, and the possibility of differences between temporal and textual ordering are ignored. Meehan acknowledges the possibility of automatically generating versions of a story that differ in order of presentation and amount of detail. Streps can be used to manipulate the alternatives. Klein's system could also be enhanced by structural considerations. In fact, two of his simulations are based on structural analyses -- Propp's characterization of Russian folktales [56] and Levi-Strauss's comparison of the mythology of neighboring South American Indian tribes [43]. However, Klein's data structure contains only events.

All considerations of text structure must be explicitly programmed for each simulation.

Even text-generators that do not produce polished natural language could account for structural features that are not considered by the systems mentioned above. The basic data structure for such a program would be a canonical form (with current techniques in artificial intelligence, expressed as a frame [46] or script [63]) for the streps to be used. Variables in this framework would include point of view, whether dialogue is to be quoted or summarized, whether conclusions are implied or explicitly stated, and so on. Concepts in the passage-dependent network for a story would include characters, time periods, and locations. A program could then select names to fill the specified functions.

If wording is to be automatically supplied, some variations in sentence structure could be selected according to structural considerations instead of on a purely random basis. For example, the active form of a statement might be generated if its subject (indicated by a pointer in the passage-dependent network) is the protagonist of a story, while the passive form would be produced otherwise.

8.3 Canonical Forms and Measures of Complexity

Canonical forms for streps have other uses. Propp's work consists of the identification of a canonical form for the structure of Russian folktales. Similar attempts can be made for other classes of texts, including programming manuals. Formalization of the "typical" computer manual, along with understanding of more common deviations, would reduce the effort needed to outline proposed documentation. In addition, such an analysis could be used in tne development of documentation standards.

Another area for future research is the development of metrics for various aspects of structural complexity. Possible measurements include the degree of interconnection among the concepts in the passage-dependent network, the number of distinct concepts, the number of concepts per passage, word or syllable, and the frequency with which concepts occur in non-adjacent passages. To compare different streps for a single text, measurements of completeness and redundancy could be developed.

Measurements of structural complexity could be used to investigate readability; features could be identified that contribute to the time a reader needs to process a text, his difficulty in understanding it, and how quickly he forgets

its content. Metrics could also be used to discover the need for some types of revision. For example, corrections might be indicated if the value of some measurement is outside a pre-specified range or if it changes dramatically from passage to passage. Metrics could also be used in attempts to identify works of questionable authorship.

The varied tasks mentioned here are difficult. They do not all involve the same structural relationships. Nevertheless, the strep is intended to allow researchers in different areas to encode features relevant to them. Furthermore, the existence of a single notation that can emphasize different aspects of text structure should ease communication among investigators in different fields.

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Glossary

acyclic network
A network in which no node is an ancestor of itself.

alphanumeric
Pertaining to characters, usually to a string of letters or digits.

ancestor
A node in a directed network that is a parent of a second node, or a parent of a parent of that node, etc.

category node
A node in a passage-dependent network that represents the interaction in meaning of its parent concepts.

child
A node in a directed network entered by an arc; the node from which the arc emanates is called the parent of the other node.

choice point
A situation during a dialogue with PERUSE in which the program displays several options and asks the user to select one.

completeness
The criterion that a representation of text structure should be applicable to entire texts and should be able to encode all needed structural relationships.

concept
A node in the passage-dependent network representing a semantic entity that recurs in a text.

concept graph
The portion of the passage-dependent network pertinent to a single concept; the concept's modifiers and subconcepts.

connected network
A network in which, for any two nodes, there is a list of nodes beginning with the first and ending with the second, such that every node on the list is either a parent or a child of the following node.

connecting phrase
A few words joining two passages; displayed by PERUSE only when both surrounding passages are also displayed.

continuous text
A sample of written natural language that forms a coherent whole.

co-occurrence node
A node in a passage-dependent network that identifies segments of text relevant to all its parent concepts without indicating that the meanings of the parent concepts combine.

co-topic
One of several subjects equally developed in a passage of text.

cross-reference
An expressed or implied suggestion within a passage of text that the reader might wish to consult another portion of the same text or a different text; also the ability to represent the recurrence of semantic entities throughout a text.

descendant
A ndoe in a directed network that is the child of another node, or the child of a child of the second node, etc.

directed network
A set of nodes and arcs, each arc emanating from one node and entering another.

ENCODE
One subsystem of THUMB; used by an expert to prepare a document for PERUSE.

essential cross-reference
Reference to a passage explaining material that is relevant to a current passage but not presented within it.

expert
Person who uses the ENCODE subsystem of THUMB.

explicit cross-reference
Explicit identification within a portion of a text of another passage.

external cross-reference
A reference within one text to another document.

flexibility
The criterion that a notation for representing text structure should allow different descriptions of a single text, emphasizing different features and providing different details.

frontier
The set of leaves in a tree.

function
The purpose of a structural element in a text, expressed in terminology pertinent to a class of texts (e.g., hero, introduction, example); also, the criterion that representations of text structure encode the function of structural elements.

functional label
An identifier attached to a node in a strep to indicate its function.

generality
The criterion that representations of text structure be applicable to different classes of text.

gratuitous cross-reference
A cross-reference to a passage that repeats information contained in the current passage.

identifier
A label attached to a node in a strep; either a name or a functional label.

implicit cross-reference
An implied suggestion that a reader consult another passage; mention of material that is explicated elsewhere.

incrementatility
The criterion that a representation of text structure should be modifiable in conjunction with revision to the represented document.

internal cross-reference
A reference to another passage within the same document.

leaf
A node in a tree that has no children.

leaf passage
A leaf node in a passage tree; a unit of text that is not further subdivided in a prticular strep.

lexicon
A list of keywords and key phrases used by THUMB to identify names and functions in a strep.

linear text
A sample of written natural language in which each word except the first has a unique following word; opposed to nonlinear text such as footnotes or tables.

mention
A reference to a subject that is not one of the primary topics of a passage of text.

modifier
A node in the passage-dependent network used to classify subconcepts of other nodes.

name
A name given to a node in a strep to identify it with terminology used in the text (e.g., the name of a character or chapter).

order
The criterion that representations of text structure encode the order in which information is presented in a text.

parent
A node in a directed network from which an arc emanates; the node where the arc enters in called the <u>child</u> of the original node.

passage
A node in a passage tree or the associated segment of text.

passage-dependent network
One of the three parts of a strep; a directed acyclic network encoding the interaction of semantic entities within particular portions of a text.

passage-independent network
One of the three parts of a strep; a semantic network encoding relations pertinent to the entire text rather than isolated passages.

passage number
An identification number assigned by ENCODE to a node in a passage tree.

passage tree
One of the three parts of a strep; a tree showing the hierarchy formed by a text's chapters, sections, paragraphs, and so on. Each division or passage may be identified by one or more names or functional labels.

PERUSE
One subsystem of THUMB; used by perusers to inspect a document interactively.

peruser
A person who uses the PERUSE subsystem of THUMB.

practicality
The criterion that representations of text structure be usable in practical applications.

root
The unique node in a tree that has no parent.

stack
A list of items arranged so that the last item entered is the first to be retrieved.

strep
Structural representation; a notation in which the structure of a text is represented by a passage tree, passage-depndent network, and passage-independent network.

subconcept
A descendant of a node (or concept) in the passge-dependent network.

tagmemics
A linguistic theory in which every syntactic unit is identified by both purpose (slot) and form (filler), for example, as a subject (slot) has the form of a noun phrase (filler).

text structure
The relations among the semantic and syntactic entities within a natural language text.

THUMB
A two-part computer system for on-line documentation. With one component, an expert perpares a manual for interactive inspection by the second component.

topic
The unique subject of a passge of text that has such a primary focus.

tree
A connected, directed network in which no node has more than one parent.

Turing test
A test of modelling of human behavior by machine; successful imitation is achieved if, hidden from both a person and a computer, a human questioner cannot identify them.

Appendix A

This appendix gives a strep for the Russian fairytale, "Frolka Stay-at-Home", along with a segmentation of the text. The passage tree is shown below. The passages have arbitrarily been assigned the identifiers P1, P2, etc. Functions are given after these identifiers. Parentheses have been used to delimit successive Proppian labels of a single passage; brackets delimit tale-types. The tree structure is shown in outline form: the immediate descendants of each passage are indented beneath it.

P1 Frolka Stay-at-Home
- P2 Title
- P3 Body
  - P4 Setting
  - P5 Absentation of Younger Generation and Violation of Implied Interdiction
  - P6 Villainy in the Form of Abduction [Motif 301 The Three Stolen Princesses]
  - P7 Mediation in the Form of a Call for Help
  - P8 Counteraction
    - P9 Consent to Counteraction
    - P10 Departure of Heroes
    - P11 Rescuing the Princesses
      - P12 Rescue of the First Princess
        - P13 Finding the Princess (Quest)
        - P14 Struggle in the Form of Battle in Open Field
          - P15 Beginning of Struggle
          - P16 Villain Beaten in Open Combat [Motif 300 The Dragon-Slayer]
        - P17 Object of Quest Obtained as Direct Result of Preceding Action
      - P18 Rescue of the Second Princess
        - P19 Finding the Princess (Quest)
        - P20 Struggle in the Form of Battle in Open Field
          - P21 Beginning of Struggle
          - P22 Villain Beaten in Open Combat [Motif 300 The Dragon-Slayer]
        - P23 Object of Quest Obtained as Direct Result of Preceding Action
      - P24 Rescue of the Third Princess
        - P25 Finding the Princess (Quest)
        - P26 Struggle in the Form of Battle in Open Field
          - P27 Beginning of Struggle
          - P28 Villain Beaten in Open Combat [Motif 300 The Dragon-Slayer]
        - P29 Object of Quest Obtained as Direct Result of Preceding Action
    - P30 Return of Hero
    - P31 Monetary Reward

The text segments associated with each terminal passage are shown below. Passages are identified with the numberings given to nodes in the passage tree as well as by page and line references to the Pantheon Books edition.

P2 Title
Page 299 Line 1

FROLKA STAY-AT-HOME

P4 Setting
Page 299 Line 2

There was once a king who had three daughers, and such beauties they were as no tongue can tell of nor pen describe. Their garden was big and beautiful and they liked to walk there at night. A dragon from the Black Sea took to visiting this garden.

P5 Absentation of Younger Generation and Violation of Implied Interdiction
Page 299 Line 6

One night the king's daughters tarried in the garden, for they could not tear their eyes away from the flowers;

P6 Villainy in the Form of Abduction [Motif 301 The Three Stolen Princesses]
Page 299 Line 8

suddenly the dragon appeared and carried them off on his fiery wings. The king waited and waited but his daughters did not come back. He sent his maidservants to look for them in the garden, but all in vain; the maidservants could not find the princesses.

P7 Mediation in the Form of a Call for Help
Page 299 Line 12

The next morning the king proclaimed a state of emergency and a great multitude of people gathered. The king said: "Whoever finds my daughters, to him I shall give as much money as he wants."

P9 Consent to Counteraction
Page 299 Line 16

Three men agreed to undertake this task--a soldier who was a drunkard, Frolka Stay-at-Home, and Erema;

P10 Departure of Heroes
Page 300 Line 1

and they set out to look for the princesses.

P13 Finding the Princess (Quest)
Page 300 Line 2

They walked and walked till they came to a deep forest. As soon as they entered it they were overwhelmed by drowsiness. Frolka Stay-at-Home drew a snuffbox out of his pocket, tapped on it, opened it, shoved a pinch of tobacco into his nose, and cried: "Eh, brothers, let us not sleep, let us not rest, let us keep going." So they went on; they walked and walked and finally came to an enormous house, and in that house was a five-headed dragon. For a long time they knocked at the gate, but no one answered. Then Frolka Stay-at-Home pushed the soldier and Erema away and said: "Let me try, brothers!" He snuffed up some tobacco and gave such a knock at the gate that he smashed it.

They entered the yard, sat in a circle, and were about to eat whatever they had. Then a maiden of great beauty came out of the house and said: "Little doves, why have you come here? A very wicked dragon lives here, who will devour you.

You are lucky that he happens to be away." Frolka answered her: "It is we who shall devour him."

P15 Beginning of Struggle
Page 300 Line 19

He had no sooner said these words than the dragon came flying and roared: "Who has ruined my kingdom? Do I have enemies in the world? I have only one enemy, but his bones won't even be brought here by a raven." "A raven won't bring me," said Frolka, "but a good horse did." The dragon upon hearing this said: "Have you come for peaceful purposes or to fight?" "I have not come for peaceful purposes," said Frolka, "but to fight."

They moved apart, faced each other, and clashed, and

P16 Villain Beaten in Open Combat [Motif 300 The Dragon-Slayer]
Page 300 Line 28

in one stroke Frolka cut off all the five heads of the dragon. Then he put them under a stone and buried the body in the ground.

P17 Object of Quest Obtained as Direct Result of Preceding Action
Page 300 Line 30

The maiden was overjoyed and said to the three brave men: "My little doves, take me with you" "But who are you?" they asked. She said that she was the king's eldest daughter; Frolka told her what task he had undertaken, and they were both glad. The princess invited them into the house, gave them meat and drink, and begged them to rescue her sisters. Frolka said: "We were sent for them too!" The princess told tnem where her sisters were. "My next sister is even worse off than I was," she said. "She is living with a seven-headed dragon." "Never mind," said Frolka, "we shall get the better of him too; it may be somewhat harder to deal with a twelve-headed dragon." They said farewell and went on.

P19 Finding the Princess (Quest)
Page 301 Line 4

Finally they came to the abode of the second sister. The house where she was locked up was enormous and all around it there was a high iron fence. They approached it and looked for the gate; finally they found it. Frolka banged upon the

gate with all his strength and it opened; they entered the yard and, as they had done before, sat down to eat.

P21 Beginning of Struggle
Page 301 Line 10

Suddenly the seven-headed dragon came flying. "I smell Russian breath here," he said. "Bah, it is you, Frolka, who have come here! What for?" "I know what for," answered Frolka. He began to fight with the dragon and

P22 Villain Beaten in Open Combat [Motif 300 The Dragon-Slayer]
Page 301 Line 13

in one stroke cut off all seven of his heads, put them under a stone, and buried the body in the ground.

P23 Object of Quest Obtained as Direct Result of Preceding Action
Page 301 Line 14

Then they entered the house; they passed through one room, a second, and a third, and in the fourth they found the king's second daughter sitting on a sofa. When they told her why

and how they had come there, she brightened, offered them food and drink, and begged them to resue her youngest sister from the twelve-headed dragon. Frolka said: "Of course, that is what we were sent for. But there is fear in my heart. Well, perhaps God will help me! Give us each another cup!"

P25 Finding the Princess (Quest)
Page 301 Line 23

They drank and left; they walked and walked till they came to a very steep ravine. On the other side of the ravine there stood enormous pillars instead of a gate, and on the pillars were chained two ferocious lions that roared so loudly that only Frolka remained standing on his feet; his two companions fell to the ground from fear. Frolka said to them: "I have seen worse terrors, and even then I was not frightened. Come with me!" And they went on. Suddenly an old man, who looked to be about seventy, came out of the castle; he saw them, came to meet them, and said: "Whither are you going, my friends?" "To this castle," answered Frolka. "Ah, my friends," said the old man, "you are going to an evil place; the twelve-headed dragon lives in this castle. He is not at home now, else he would have

devoured you at once." "But he is the very one we have come to see," said Frolka. "If so," said the old man, "come with me, I will help you get to him." The old man went up to the lions and began to stroke them, and Frolka with his companions got through to the courtyard.

They entered the castle; the old man brought them to the room where the princess lived. Upon seeing them she quickly jumped off her bed and began to question them as to who they were and why they had come. They told her. The princess offered them food and drink and began to make ready to go.

P27 Beginning of Struggle
Page 302 Line 8

As they were preparing to leave the house, they suddenly saw the dragon flying at a verst's distance from them. The king's daughter rushed back into the house and Frolka and his companions went out to meet and fight the dragon. At first the dragon attacked them with great force, but

P28 Villain Beaten in Open Combat [Motif 300 The Dragon-Slayer]
Page 302 Line 12

Frolka, a clever fellow, managed to defeat him, cut off all of his twelve heads, and cast them into the ravine. Then they returned to the house

P29 Object of Quest Obtained as Direct Result of Preceding Action
Page 302 Line 15

and in their joy reveled even more than before. Following this feast they set out on ther way, stopping only for the other princesses.

P30 Return of Hero
Page 302 Line 18

Thus they all came back to their native land.

P31 Monetary Reward
Page 302 Line 18

The king was overjoyed, opened his royal treasury to them, and said: "Now, my faithful servants, take as much money as

you want for a reward." Frolka was generous: he brought his big three-flapped cap, the soldier brought his knapsack, and Erema brought a basket. Frolka began to fill his cap first: he poured and poured, the cap broke, and the silver fell into the mud. Frolka began to pour again; he poured, and the money dropped from the cap! "There is nothing to be done," said Frolka. "Probably all of the royal treasury will fall to me." "And what will be left for us?" asked his companions. "The king has enough money for you too," said Frolka. While there was still money, Erema began to fill his basket, and the soldier his knapsack; having done this, they went home. But Frolka remained near the royal treasury with his cap and to this very day he is still sitting there, pouring out money for himself. When his cap is filled, I shall go on with my story, but now I am too tired.

The passage-dependent network is shown below. The nodes have arbitrarily been assigned the identifiers N1, N2, etc. Most nodes are category nodes. Nodes (e.g., N7) marked with an asterisk are co-occurrence nodes. Labels are shown in brackets. Unlabelled nodes have been given descriptive names. Under each node is a list of its

immediate descendants within the passage-dependent network and the passages in the passage tree to which it points.

N1 [Characters]
N2, N3, N8, N13

N2 King [Tsar]
P4, P6, P7, P31

N3 [Princesses]
N4, N5, N6

N4 First Princess
P12, N7

N5 Second Princess
P18, N7, N20

N6 Third Princess
P24, N7, N21

N7# Co-occurrences of Princesses
P4, P5, P6, P30, N19

N8 [Heroes]
N9, N10, N11

N9 Frolka Stay-at-Home
N12

N10 Soldier
N12

N11 Erema
N12

N12# Co-occurrences of Heroes
P8, P30, P31

N13 [Villains]
N14, N15, N16, N17

N14 Dragon from the Black Sea
P4, P6

N15 Five-Headed Dragon
P14, N22

N16 Seven-Headed Dragon
P20, N23

N17 Twelve-Headed Dragon
P26, N24

N18 Characters Discussed by Others
N19, N20, N21, N22, N23, N24

N19 Discussion of the Princesses
P7

N20 Discussion of the Second Princess
P17

N21 Discussion of the Third Princess
P17, P23

N22 Discussion of the Five-Headed Dragon
P13

N23 Discussion of the Seven-Headed Dragon
P17

N24 Discussion of the Twelve-Headed Dragon
P17, P23, P25

N25 [Places]
N26, N27, N28, N29

N26 Tsar's Kingdom
P4, P5, P6, P7, P9, P10, P30, P31

N27 Kingdom of the Five-Headed Dragon
P12

N28 Kingdom of the Seven-Headed Dragon
P18

N29 Kingdom of the Twelve-Headed Dragon
P24

Some of the information that might be indicated in a passage-independent network for Frolka Stay-at-Home is shown below. The generic form of each item is subject-relation-object. The relationships are grouped by subject; objects are underlined. To increase readability by normal English word order, acts are listed as relations with their agent as subject; other cases (and attributes) are identified in parentheses. Instead of arbitrary values for the attribute, "age", the relationship, "older than", is used to indicate the relative ages of the princesses. Relative distances among the various places mentioned in the story are similarly encoded.

Correspondence to the text is not indicated here. The passage-dependent network could be used to relate a node for each act to specific text segments.

Frolka Stay-at-Home
leader of soldier
leader of Erema
defeats (location: home of Five-Headed Dragon) Five-Headed Dragon
defeats (location: home of Seven-Headed Dragon) Seven-Headed Dragon
defeats (location: home of Twelve-Headed Dragon) Third Dragon
rescues (location: home of Five-Headed Dragon) First Princess
rescues (location: home of Seven-Headed Dragon) Second Princess
rescues (location: home of Twelve-Headed Dragon) Third Princess

soldier
fights (location: home of Five-Headed Dragon) Five-Headed Dragon
fights (location: home of Seven-Headed Dragon) Seven-Headed Dragon
fights (location: home of Twelve-Headed Dragon) Third Dragon
rescues (location: home of Five-Headed Dragon) First Princess
rescues (location: home of Seven-Headed Dragon) Second Princess
rescues (location: home of Twelve-Headed Dragon) Third Princess

Erema
fights (location: home of Five-Headed Dragon) Five-Headed Dragon
fights (location: home of Seven-Headed Dragon) Seven-Headed Dragon
fights (location: home of Twelve-Headed Dragon) Third Dragon
rescues (location: home of Five-Headed Dragon) First Princess
rescues (location: home of Seven-Headed Dragon) Second Princess
rescues (location: home of Twelve-Headed Dragon) Third Princess

dragon
kidnaps (location: Tsar's Kingdom) First Princess
kidnaps (location: Tsar's Kingdom) Second Princess
kidnaps (location: Tsar's Kingdom) Third Princess
gives (object: First Princess, recepient: Five-Headed Dragon, location: Home of Five-Headed Dragon)
gives (object: Second Princess, recepient: Seven-Headed Dragon, location: Home of Seven-Headed Dragon)
gives (object: Third Princess, recepient: Twelve-Headed Dragon, location: home of Twelve-Headed Dragon)

Five-Headed Dragon
lives in Home of Five-Headed Dragon
has heads (number: 5)

Seven-Headed Dragon
lives in Home of Seven-Headed Dragon
has heads (number: 7)

Twelve-Headed Dragon
   lives in Home of Twelve-Headed dragon
   has heads (number: 12)

First Princess
   older than Second Princess

Second Princess
   older than Third Princess

Tsar
   father of First Princess
   father of Second Princess
   father of Third Princess
   offers reward (purpose: rescue of Princess, recepient:
        anyone, location: Tsar's Kingdom)
   rewards (object: money, recepient: Frolka, location:
        Tsar's Kingdom)
   rewards (object: money, recepient: Erema, location:
        Tsar's Kingdom)
   rewards (object: money, recepient: soldier, location:
        Tsar's Kingdom)

Home of Five-Headed Dragon
   far from Tsar's Kingdom

Home of Seven-Headed Dragon
   far from Home of Five-Headed Dragon

Home of Twelve-Headed Dragon
   far from Home of Seven-Headed Dragon

Appendix B

This appendix shows the passage tree and the passage-dependent network of a strep for the children's book, When an Animal Grows. The passage tree is shown below. Each passage has been given a name to indicate its contents. Leaf passages have also been given the names "brown" or "green", shown in parentheses, to indicate whether they are printed in brown or green ink in the text. In addition, the arbitrary identifiers P1, P2, ... have been assigned to the passages. The tree structure is shown in outline form; the immediate descendants of each node are indented beneath it.

P1 When an Animal Grows
  P2 Title
  P3 Body
    P4 Introduction
      P5 (Brown) Story of a Gorilla
      P6 (Green) Story of a Lamb
      P7 Animals Grow at Different Rates
        P8 Mammals
          P9 (Brown) Gorilla
          P10 (Brown) Lamb
          P11 (Brown) Mammals Grow at Different Rates
          P12 (Brown) Gorilla
          P13 (Green) Lamb
        P14 Birds

P15 (Green) Birds Grow at Different Rates
P16 (Green) Sparrows
P17 (Brown) Ducks
P18 (Green) All Animals
P19 Mammals
P20 Newborn
P21 Eating and Sleeping
P22 (Brown) Gorilla
P23 (Green) Lamb
P24 With Other Animals
P25 (Brown) Gorilla
P26 (Green) Lamb
P27 Early Infancy
P28 Straying from Mother's Side
P29 Gorilla
P30 (Brown) Age
P31 (Brown) Description
P32 Lamb
P33 (Green) Age
P34 (Green) Description
P35 Diet
P36 Gorilla
P37 (Brown) Age
P38 (Brown) Description
P39 (Green) Lamb
P40 Gorilla at 6 Months
P41 (Brown) Age
P42 (Brown) Description
P43 Childhood
P44 Playing
P45 Follow-the-Leader
P46 Gorilla
P47 (Brown) Age
P48 (Brown) Description
P49 Lamb
P50 (Green) Age
P51 (Green) Description
P52 King of the Mountain
P53 (Brown) Gorilla
P54 (Green) Lamb
P55 Fighting
P56 (Brown) Gorilla
P57 (Green) Lamb
P58 Playing Alone
P59 (Brown) Gorilla
P60 (Green) Lamb
P61 Spending Time with Mother

P62 (Brown) Gorilla
P63 (Green) Lamb
P64 Following Mother
P65 (Brown) Gorilla
P66 (Green) Lamb
P67 Weaning
P68 (Brown) Gorilla
P69 (Green) Lamb
P70 Becoming Full Grown
P71 (Green) Lamb
P72 (Brown) Gorilla
P73 Birds
P74 (Green) Introduction
P75 Body
P76 Eggs
P77 (Green) Sparrows
P78 (Brown) Ducks
P79 Hatching
P80 Sparrows
P81 (Green) Age
P82 (Green) Pecking
P83 (Green) Number
P84 (Green) Variety
P85 Ducks
P86 (Brown) Age
P87 (Brown) Pecking
P88 (Brown) Number
P89 (Brown) Variety
P90 Newly Hatched
P91 Sparrows
P92 (Green) Introduction
P93 (Green) Feathers
P94 (Green) See
P95 (Green) Walk
P96 Ducks
P97 (Brown) Introduction
P98 (Brown) Feathers
P99 (Brown) See
P100 (Brown) Walk
P101 Diet
P102 Sparrows
P103 (Green) Eating
P104 (Green) Father's Help
P105 (Green) Protected by Mother
P106 Ducks
P107 (Brown) Eating

P108 (Brown) Protected by Mother
P109 (Brown) Father's Help
P110 Starting to Grow
P111 Sparrows
P112 Three Days
P113 (Green) Age
P114 (Green) Description
P115 Six Days Old
P116 (Green) Age
P117 (Green) Description
P118 Eight Days Old
P119 (Green) Age
P120 (Green) Description
P121 Ten Days Old
P122 (Green) Age
P123 (Green) Description
P124 Next Few Days
P125 (Green) Age
P126 (Green) Description
P127 (Green) Danger
P128 (Brown) Ducks in Danger
P129 Becoming Full Grown
P130 Sparrows
P131 Seventeen Days Old
P132 (Green) Age
P133 (Green) Description
P134 Twenty-One Days Old
P135 (Green) Age
P136 (Green) Description
P137 One Month Old
P138 (Green) Age
P139 (Green) Description
P140 Ducks
P141 (Brown) Age
P142 (Brown) Description
P143 Flying South
P144 (Brown) Ducks
P145 (Green) Sparrows

P146 (Green) Conclusion

The text segments associated with each terminal passage are shown below. Passages are identified with the numberings given to nodes in the passage tree as well as by page and line references to the text.

P2 Title
Page 1 Line 1

When an Animal Grows

P5 (Brown) Story of a Gorilla
Page 6 Line 1

This is the story of a baby gorilla. He is very little and weak. He is one day old.

P6 (Green) Story of a Lamb
Page 7 Line 1

And this is the story of a lamb that grows up to be a sheep. This lamb was born just half an hour ago. But already she can stand up on her wobbly legs.

P9 (Brown) Gorilla
Page 8 Line 1

The baby gorilla will grow.

P10 (Brown) Lamb
Page 8 Line 2

And the lamb will grow.

P11 (Brown) Mammals Grow at Different Rates
Page 8 Line 3

But they will grow in different ways.

P12 (Brown) Gorilla
Page 8 Line 4

Some animals grow slowly, like the gorilla that is helpless at first.

P13 (Green) Lamb
Page 8 Line 6

And some grow fast, like the lamb.

P15 (Green) Birds Grow at Different Rates
Page 9 Line 1

Birds grow in different ways too.

P16 (Green) Sparrows
Page 9 Line 2

When a sparrow comes from an egg, it can't see and has no feathers.

P17 (Brown) Ducks
Page 9 Line 4

But a duck walks and swims after its mother, soon after hatching.

P18 (Green) All Animals
Page 9 Line 6

Either way, an animal grows. It gets bigger and bigger. And before long it is grown-up and able to take care of itself.

P22 (Brown) Gorilla
Page 10 Line 1

The baby gorilla's mother has milk to nurse her baby. She holds him tight. At night the baby gorilla sleeps with his mother in a nest of branches. He is with her all the time.

P23 (Green) Lamb
Page 11 Line 1

The mother sheep has milk for her baby too. Soon the lamb finds the right spot. She fills her stomach with warm milk. This makes her sleepy. The lamb nurses and sleeps, and nurses and sleeps.

P25 (Brown) Gorilla
Page 12 Line 1

Mother and baby gorilla are not alone. They live with other gorillas in the forest. The band of gorillas is resting. They have just eaten a lot of leaves, stems, and roots. They are ready to move on to a new place. The big, old gorilla with silver hair on his back gives the signal. He is the leader. The mother gorilla picks up her baby in one arm and carries him close to her chest. Now she walks on two legs and one arm.

P26 (Green) Lamb
Page 14 Line 1

The mother sheep is not alone either. She lives with many other mother sheep and their lambs in a flock. The baby lamb follows her mother. She runs along at her side. She starts to nibble at the grass. The oldest mother sheep in the flock gives a signal when it is time to move. She is the leader. The mother sheep follows the others. The baby lamb follows her.

P30 (Brown) Age
Page 16 Line 1

The baby gorilla grows and grows. Now he is three months old.

P31 (Brown) Description
Page 16 Line 3

Now when his mother puts him on the ground, he can crawl away. But not too far. If he does, the mother gorilla pulls him back to her side.

P33 (Green) Age
Page 17 Line 1

The baby lamb is only a few weeks old.

P34 (Green) Description
Page 17 Line 2

When she goes too far away, the mother sheep calls "Baaaaa." And the baby lamb runs to her side. If the baby lamb gets lost, she calls "Baaaaa." The mother sheep hears her cry and goes to find her.

P37 (Brown) Age
Page 18 Line 1

The three-month-old baby gorilla

P38 (Brown) Description
Page 18 Line 2

starts to ride on his mother's back. As he rides he slaps the leaves. Sometimes he grabs a bit of a plant and stuffs it into his mouth. He has teeth now. He can eat leaves and stems.

P39 (Green) Lamb
Page 19 Line 1

The little lamb nurses less and less and eats more and more grass.

P41 (Brown) Age
Page 20 Line 1

The baby gorilla keeps growing. He is six months old now.

P42 (Brown) Description
Page 20 Line 3

He is still getting milk from his mother, but he is eating more and more plants. Already he can climb by himself. He can walk behind his mother. He can swing sideways and upside down.

P47 (Brown) Age
Page 22 Line 1

Now the baby gorilla is a year old.

P48 (Brown) Description
Page 22 Line 2

When his mother rests, he plays with other baby gorillas. Four of them are playing a game. It looks like follow-the-leader that children play. The leader runs along a branch. The others follow. The leader climbs up a vine. The others follow. The leader slides down. The others slide down too. The leader holds on to a vine and stretches way out. Snap! The vine breaks. The leader falls. And down after him come his friends, vine leaves and all. They tumble softly into the leaves below.

P50 (Green) Age
Page 24 Line 1

The baby lamb plays with other lambs when she is only a few weeks old.

P51 (Green) Description
Page 24 Line 3

Lambs play follow-the-leader too. They run after each other through the green fields. They jump on the rock. They jump off the rock. If one jumps up and turns around in the air, the others jump up and turn around in the air.

P53 (Brown) Gorilla
Page 26 Line 1

Baby gorillas play another game. It is like our "king of the mountain." One baby gorilla sits on a stump. The others try to push him off. Bang! He gives them a kick. He is still king of the mountain. He stays there until another baby gorilla pushes him off. Then there is a new king.

P54 (Green) Lamb
Page 27 Line 1

Lambs play king of the mountain too.

P56 (Brown) Gorilla
Page 28 Line 1

Baby gorillas wrestle. Here one of them has a headlock on another one.

P57 (Green) Lamb
Page 29 Line 1

Here is a fight between two baby lambs. They are facing each other. Their heads are low. They charge! Crack! Their heads bang together. Then they move away. Then they do it again. It's just a game!

P59 (Brown) Gorilla
Page 30 Line 1

Sometimes baby gorillas play by themselves. The leaves are their toys. Here is a baby gorilla with a big bunch of leaves in his hand. He bangs them on the ground. He swings

them over his head. Sometimes he tears the leaves with his hands and lets them slowly fall around him in a green shower. Sometimes he puts the leaves upside down on his head and just sits under his hat.

P60 (Green) Lamb
Page 31 Line 1

But baby lambs always play together.

P62 (Brown) Gorilla
Page 32 Line 1

Every once in a while the baby gorilla goes to sit near his mother.

P63 (Green) Lamb.
Page 33 Line 1

The baby lamb goes to her mother too, every once in a while. She lies down next to her in the shade of a big tree.

P65 (Brown) Gorilla
Page 34 Line 1

When the mother gorilla moves through the forest the baby gorilla still rides on her back or he may walk behind her.

P66 (Green) Lamb
Page 35 Line 1

When the mother sheep gets on her feet and starts to walk away, the little lamb gets up too and follows her mother.

P68 (Brown) Gorilla
Page 36 Line 1

The baby gorilla gets less and less milk from his mother. By the time he is a year and a half old, he eats only stems, roots, and leaves. But he still stays close to his mother when he is not playing.

P69 (Green) Lamb
Page 37 Line 1

The little lamb nurses only for a few months. Then she eats only grass.

P71 (Green) Lamb
Page 37 Line 4

She is grown-up. When she is a year old, she can have a little lamb of her own.

P72 (Brown) Gorilla
Page 38 Line 1

But the baby gorilla is still growing. He grows and grows. He stays with his mother until he is three years old. Now he makes his own nest to sleep in at night. His mother has had another baby. The new baby is small and weak. It needs its mother. But the young gorilla is big enough now to take care of himself. He takes his place in the gorilla band.

P74 (Green) Introduction
Page 40 Line 1

Birds, like other animals, grow too.

P77 (Green) Sparrows
Page 40 Line 2

These are sparrow's eggs.

P78 (Brown) Ducks
Page 41 Line 1

These are duck's eggs.

P81 (Green) Age
Page 42 Line 1

The baby sparrows grow inside the eggs for twelve days.

P82 (Green) Pecking
Page 42 Line 3

Now they are pecking at their shells. They will soon be out.

P83 (Green) Number
Page 42 Line 5

Here is one. Here is another. Here is sparrow number three. And here is number four.

P84 (Green) Variety
Page 42 Line 8

They are Song Sparrows.

P86 (Brown) Age
Page 43 Line 1

The baby ducks grow inside the eggs for almost a month.

P87 (Brown) Pecking
Page 43 Line 3

Then they begin to peck at their shells.

P88 (Brown) Number
Page 43 Line 5

Now a wet little duckling comes out. Now another comes out. And another. And another. And another and another and another and another.

P89 (Brown) Variety
Page 43 Line 10

They are Mallard ducklings.

P92 (Green) Introduction
Page 44 Line 1

The little sparrows are in a nest hidden in the grass. They are tiny and helpless.

P93 (Green) Feathers
Page 44 Line 4

They have no feathers.

P94 (Green) See
Page 44 Line 5

They can't see.

P95 (Green) Walk
Page 44 Line 5

They can't walk.

P97 (Brown) Introduction
Page 45 Line 1

How different the ducklings are.

P98 (Brown) Feathers
Page 45 Line 2

They have soft little feathers.

P99 (Brown) See
Page 45 Line 3

They can see.

P100 (Brown) Walk
Page 45 Line 4

As soon as the ducklings are dry, the mother duck clucks quietly. She leaves the nest. The little ducks follow. The mother duck walks into the water. She swims. The ducklings waddle into the water. They swim too.

P103 (Green) Eating
Page 46 Line 1

Here comes the mother sparrow with food. Up go four heads. Four mouths open. The baby sparrow with his head the highest and his beak open the widest gets fed. The mother sparrow flies away. She comes back with more food. Now another baby sparrow gets the food.

P104 (Green) Father's Help
Page 47 Line 1

Father sparrow brings food too. Both parents are busy all day long catching insects take back to the nest.

P105 (Green) Protected by Mother
Page 47 Line 5

When it is cold, or if the sun is too hot, mother sparrow spreads her wings her wings over the little sparrows.

P107 (Brown) Eating
Page 48 Line 1

The ducklings do not have to be fed. They find their own food on the water. They eat any bugs, beetles, or flies on top of the water. The mother duck tips down into the water and eats the plants and seeds she finds there.

P108 (Brown) Protected by Mother
Page 49 Line 1

At night the mother duck leads her ducklings to the shore. She spreads her wings over them and keeps them warm.

P109 (Brown) Father's Help
Page 49 Line 5

The father duck goes off by himself. The mother duck takes care of the ducklings.

P113 (Green) Age
Page 51 Line 1

The little sparrows grow bigger. Here they are three days old.

P114 (Green) Description
Page 51 Line 3

Their feathers are starting to grow. Their eyes are beginning to open. The mother and father sparrow keep bringing food.

P116 (Green) Age
Page 51 Line 7

The little sparrows grow and grow. Six days old.

P117 (Green) Description
Page 51 Line 2

The sparrows can stand up now. Their feathers are growing longer and longer. Their eyes are wide open.

P119 (Green) Age
Page 52 Line 1

Eight days old.

P120 (Green) Description
Page 52 Line 2

The sparrows are well covered with feathers. They move around in the nest. They even climb to the edge.

P122 (Green) Age
Page 53 Line 1

Ten days old.

P123 (Green) Description
Page 53 Line 2

The sparrows are about to hop out of the nest. Here goes one. And another. And the next. And the last. They are all gone. The sparrows do not go too far. They move around in the bushes near the nest.

P125 (Green) Age
Page 54 Line 1

During the next few days

P126 (Green) Description
Page 54 Line 1

they start to fly. Each little sparrow is alone. But each one can hear the mother and father sparrow. And the mother and father sparrow can hear them. When they call "Eep!" their parents can find them in the bushes and give them food.

P127 (Green) Danger
Page 54 Line 10

If danger is near, the mother or father sparrow calls "Tik, tik, tik," and the young sparrows keep very quiet. Then they are hard to find.

P128 (Brown) Ducks in Danger
Page 56 Line 1

But where do the ducklings hide when there is danger? Here comes a turtle. The mother duck cries out. The ducklings clump together behind her. But now the turtle is too close. The mother duck quacks loudly. The ducklings hide in the water plants. The mother duck flaps her wings. The turtle follows, but she keeps ahead. When they are far from the ducklings, the mother duck flies up into the air. She goes back and calls her ducklings. They come to her. They are safe now.

P132 (Green) Age
Page 58 Line 1

The sparrrows stay in the bushes around the nest until they are seventeen days old.

P133 (Green) Description
Page 58 Line 4

Then they come out of hiding. The four baby sparrows find each other again. They can fly well now.

P135 (Green) Age
Page 58 Line 8

The sparrows are twenty-one days old.

P136 (Green) Description
Page 58 Line 9

They still follow their parents for food, even though they can find their own food now. When father sparrow sings, they pop up beside him. Sometimes they land on top of him!

P138 (Green) Age
Page 59 Line 1

At one month the sparrows are grown-up.

P139 (Green) Description
Page 59 Line 2

They feed themselves. They fly around. They call "Tsip, tsip" to each other.

P141 (Brown) Age
Page 60 Line 1

The ducklings take longer to grow up. All through the warm days of summer they swim, eat, and rest.

P142 (Brown) Description
Page 60 Line 4

It is two months before they have all the feathers they need to fly. Here is one young duck scooting across the water. His wings are flapping. Another week or so and the whole family of ducklings is flying. The duck family is grown-up now.

P144 (Brown) Ducks
Page 62 Line 2

The young ducks join other ducks. And one day in the fall, flock after flock takes to the air and flies south.

P145 (Green) Sparrows
Page 63 Line 1

The young sparrows fly south in the fall too.

P146 (Green) Conclusion
Page 64 Line 1

Next year the birds will fly back north. The sparrows and ducks that were babies the year before will raise their own families.

The passage-dependent network is shown below. The nodes have arbitrarily been assigned the identifiers N1, N2, etc. Each node has been given a descriptive name. Under each node is a list of its immediate descendants within the passage-dependent network and the passages in the passage tree to which it points.

N1 Animals
N2, N5

N2 Mammals
N3, N4

N3 Gorilla
N9, N14, N17, N22, N29, N32, N34, N39, N43, N56, N58, N69, N92, N94, N96, N98, N105

N4 Lamb
N10, N15, N18, N23, N30, N33, N35, N40, N59, N63, N93, N95, N97, N99, N101, N106

N5 Birds
N6, N7

N6 Sparrows
N11, N20, N24, N36, N49, N50, N53, N64, N73, N77, N79, N82, N85, N102, N107, N110, N113, N116, N119

N7 Ducks
N12, N19, N25, N37, N51, N54, N55, N71, N74, N76, N80, N83, N86, N103, N108, N111, N114, N117, N120

N8 Age
N9, N10, N11, N12

N9 Age of Gorilla
P5, P30, P37, P41, P47, P68, P72

N10 Age of Lamb
P6, P33, P50, P69, P71

N11 Age of Sparrows
P16, P81, P113, P116, P119, P122, P125, P132, P135, P138

N12 Age of Ducks
P17, P86, P141

N13 Story
N14, N15

N14 Story of Gorilla
P5

N15 Story of Lamb
P6

N16 Rate of Growth
N17, N18, N19, N20

N17 Growth Rate of Gorilla
P9

N18 Growth Rate of Lamb
P10

N19 Growth Rate of Ducks
P16

N20 Growth Rate of Sparrows
P17

N21 New
N22, N23, N24, N25

N22 New Gorilla
P5, P9, P11, P22, P25

N23 New Lamb
P6, P10, P11, P23, P26

N24 New Sparrows
P16, P80

N25 New Ducks
P17, P85

N26 Eating
N27, N46

N27 Diet
N28, N34, N35, N36, N37

N28 Nursing
N29, N30, N31

N29 Nursing Gorilla
P22, P42

N30 Nursing Lamb
P23, P39

N31 Weaning
N32, N33

N32 Weaning Gorilla
P68

N33 Weaning Lamb
P69

N34 Diet of Gorilla
P22 P38 P42 P68

N35 Diet of Lamb
P26, P39, P71

N36 Diet oF Sparrows
P103, P104, P126

N37 Diet of Ducks
P107

N38 Sleeping
N39, N40

N39 Sleeping Gorilla
P22, P72

N40 Sleeping Lamb
P23

N41 Relationship with Parents
N42, N48

N42 Relationship with Mother
N43, N44, N45, N47, N52

N43 Gorilla Carried by Mother
P25, P38

N44 Coming When Called
N56, N57

N45 Following Mother
N58, N59

N46 Being Fed
N47, N49

N47 Being Fed by Mother
N28, N50, N51

N48 Relationship with Father
N49, N55

N49 Sparrows Fed by Father
P104, P114, P126, P136, P139

N50 Sparrows Fed by Mother
P103, P114, P126, P136, P139

N51 Ducks Not Fed by Mother
P107, P141

N52 Protected by Mother
N53, N54

N53 Sparrows Protected by Mother
P105

N54 Ducks Protected by Mother
P108

N55 Ducks Neglected by Father
P109

N56 Gorilla Coming When Called
P31

N57 Lamb Coming When Called
P34

N58 Gorilla Following Mother
P42, P62, P65, P68,

N59 Lamb Following Mother
P26, P63, P66

N60 Basic Skills
N61, N75

N61 Moving
N62, N65, N69, N70, N71, N72

N62 Standing
N63, N64

N63 Lamb Standing
P6

N64 Sparrows Standing
P117

N65 Walking
N66, N67, N68

N66 Duck Walking
P17 P100

N67 Gorilla Walking
P42

N68 Sparrows Walking
P95, P120, P123

N69 Gorilla Crawling
P31

N70 Gorilla Climbing and Swinging
P42

N71 Ducks Swimming
P17, P100, P141

N72 Flying
N73, N74

N73 Sparrows Flying
P126, P133

N74 Ducks Flying
P142

N75 Seeing
N76, N77

N76 Ducks See
P99

N77 Sparrows See
P16, P94, P117

N78 Feathers
N79, N80

N79 Sparrows' Feathers
P16, P93, P114, P117, P120

N80 Ducks' Feathers
P98

N81 Hatching
N82, N83

N82 Sparrows Hatching
P82

N83 Ducks Hatching
P87

N84 Eggs
N85, N86

N85 Sparrows' Eggs
P16 P77

N86 Ducks' Eggs
P78

N87 Playing
N88, N89, N90, N91

N88 Follow-the-Leader
N92, N93

N89 King-of-the-Mountain
N94, N95

N90 Fighting
N96, N97

N91 Playing Alone
N98, N99

N92 Gorillas Play Follow-the-Leader
P48

N93 Lambs Play Follow-the-Leader
P51

N94 Gorillas Play King-of-the-Mountain
P53

N95 Lambs Play King-of-the-Mountain
P54

N96 Gorillas Fight
P56

N97 Lambs Fight
P57

N98 Gorillas Play Alone
P59

N99 Lambs Don't Play Alone
P60

N100 Having Own Babies
N101, N102, N103

N101 Lamb Having Babies
P71

N102 Sparrows Having Babies
P146

N103 Ducks Having Babies
P146

N104 Growing Up
N105, N106, N107, N108

N105 Gorilla Growing Up
P72

N106 Lamb Growing UP
P71

N107 Sparrows Growing UP
P145

N108 Ducks Growing Up
P144

N109 Flying South
N110, N111

N110 Sparrows Flying South
P145

N111 Ducks Flying South
P144

N112 Number of Babies in the Nest
N113, N114

N113 Four Sparrows
P83

N114 Eight Ducklings
P88

N115 Variety
N116, N117

N116 Song Sparrows
P84

N117 Mallard Ducks
P89

N118 Danger
N119, N120

N119 Sparrows in Danger
P127

N120 Ducks in Danger
P128

Appendix C

This appendix shows the passage tree and the passage-depndent network of a strep for the ASCII FORTRAN Supplement, along with a segmentation of the text. The passage tree is shown below. The passages have arbitrarily been assigned the identifiers P1, P2, etc. Names and labels for each passage are listed after these P numbers; labels are enclosed in square brackets.

P1 ASCII Fortran Supplement
- P2 [Preliminary Material]
  - P3 [Title]
  - P4 [Introduction]
  - P5 [Table of Contents]
- P6 [Body]
  - P7 FTN Compiler Option Changes
    - P8 [Title]
    - P9 E-option
    - P10 F-option
    - P11 T-option
    - P12 X-option
    - P13 Y-option
  - P14 Collection of FTN Programs
  - P15 FTN Walkback and Interactive Postmortem Dump
    - P16 [Title]
    - P17 [Introduction]
    - P18 Occurrences
      - P19 Walkback and Interactive PMD occur on
      - P20 Walkback also occurs on
      - P21 Interactive PMD also occurs on
    - P22 FTN Walkback

The text segments associated with each terminal passage are shown below. Passages are identified with the numberings given to nodes in the passage tree as well as by page and line references to the text.

The table of contents is treated as a single segment. When a section is not subdivided into several passages, any section heading is included as part of the single passage comprising the section. When the material in one section is segmented into several passages, the section heading is placed into a passage by itself.

P3 [Title]
Page 1 Line 1

ASCII FORTRAN SUPPLEMENT

Supplement for FTN PRM Level: 8244 Rev. 1; Compiler Level: 6R1

P4 [Introduction]
Page 1 Line 3

This document was prepared for use at MACC as an interim supplement to the Ascii Fortran (FTN) compiler manual. It is intended to bridge the gap between the current level of documentation for FTN released by Univac and the current compiler level. Several extensions, enhancements, and changes to the compiler and its library, are described. No attempt is being made at present by MACC to correct errors in the current level of FTN documentation as this is currently being undertaken by Univac.

P5 [Table of Contents]
Page 1 Line 15

TABLE OF CONTENTS

P8 [Title]
Page 2 Line 1

FTN Compiler Option Changes

P9 E-option
Page 2 Line 2

E-option.

This option, identical to the Ascii Fortran 'COMPILER(U1110=OPT)' directive, invokes a code-reordering algorithm, increasing the execution speed of the object module on 1110 hardware. The speed enhancement is not reflected in CAU charges since they are based on storage reference counts -- not execution time, but can improve system throughput on "CPU bound" systems.

P10 F-option
Page 2 Line 12

F-option.

The interactive PMD and walkback features are enabled when the F-option is used (cf. pages 3-6,13).

P11 T-option
Page 2 Line 16

T-option.
Since this option causes compilation of calls to the I/O library with LMJ's rather than LIJ's and MACC's version of FTN uses the Common Bank I/O system, this option is not to be used.

P12 X-option
Page 2 Line 22

X-option.
The X-option causes the compiler to perform an ER ABORT$ if a contingency occurs. If the compilation contains errors, an ER ABORT$ is done after the END FTN message.

P13 Y-option
Page 2 Line 27

Y-option.
This option produces both the shortened generated code listing (no octals) as well as the storage map, common blocks, and entry point listings of the D-option.

P14 Collection of FTN Programs
Page 2 Line 32

Collection of FTN Programs

Any Ascii Fortran program that is compiled without the C-option (CHECKOUT load-and-go) must be explicitly collected with @MAP using the LIB FTN*LIB. directive. If the O-option is used to compile Ascii Fortran programs with D-Banks larger than 65K, then the E-option should be used with @MAP in the collection.

P16 [Title]
Page 3 Line 1

FTN Walkback and Interactive Postmortem Dump

P17 [Introduction]
Page 3 Line 2

Both Walkback and Interactive PMD are available on collected absolutes when the F-option was used to compile symbolics into relocatables.

P19 Walkback and Interactive PMD occur on:
Page 3 Line 5

Walkback and Interactive PMD occur on:
* Math Library Error
* Error in the I/O Library
* Illegal Operation (IOPR)
* Guard Mode (IGDM)

```
          # Error Mode


P20   Walkback also occurs on:
Page 3                  Line  11

     Walkback also occurs on:
          # Execution of the Fortran statement:
               CALL FTNWB


P21   Interactive PMD also occurs on:
Page 3                  Line  14

     Interactive PMD also occurs on:
          # Execution of the Fortran statement:
               CALL FTNPMD
          # Break Keyin (BREAK followed by @@X C)


P23   [General Description]
Page 3                  Line  18

     FTN WALKBACK

          Walkback gives the absolute address where an error
          or call to FTNWB occurred as well as ISN's
          (Internal Statement Numbers) of the current
          nesting of subroutine and function calls as far
          back as the main program if all relocatables were
          compiled using the F-option.  Notice that the
          walkback includes all external subprograms whether
          compiled in the same or distinct elements.  See
          example on next page.
```



```
P24   [Example]
Page 4                  Line  1

     FTN WALKBACK EXAMPLE:

     FTN Source Code:   CALL S1
                        END

                        SUBROUTINE S1
                        CALL S2
                        RETURN
                        END

                        SUBROUTINE S2
                        DIMENSION A(2)
                        PRINT *,A(100 000)
                        RETURN
                        END

     Resulting Execution:

      GUARD MODE   ERR-CODE:02
      ERROR ADDRESS: 007677    BDI:  400025
      THIS ADDRESS IS IN COMMON I/O BANK  C2F$
      I/O     REFERENCED AT ISN     9  OF  S2
      S2      REFERENCED AT ISN     4  OF  S1
      S1      REFERENCED AT ISN     1  OF MAIN PROGRAM

      *****  ENTER FTN PMD  *****
      -D I

      >>> ELEMENT NAME$        <<<

      A       /S2      /NAME$

      ** FORTRAN DUMP ROUTINE **      VARIABLE ADDRESSES...

      050402     .00000000       .00000000
      -EXIT

      *****  EXIT FTN PMD  *****
      USER DID AN ER EABT$
       REENT ADDR:047773  BDI:200005
```

P27 [Title]
Page 5 Line 1

FTN INTERACTIVE POSTMORTEM DUMP

P28 [Demand Use]
Page 5 Line 2

Demand use: (input is solicited with a '-' character)

Commands: (optional fields enclosed in brackets '[]')

D[UMP][,opt] !

dumps all variables in all program units in all elements.

D[UMP][,opt] [var]/[prg]/elt

where

var is : a scalar variable name
: an array name
: an array element with constant subscripts
: omitted, dumping all varaibles

prg is : '*' for the main program
: a subroutine name or function name
: n for the n-th block data subroutine
: omitted for the first program unit in an element

elt is : a relocatable element name

opt is : 'A' for an Ascii alphabetic dump
: 'O' for an octal dump
: omitted for a dump using the type assigned by the compiler

Blanks can appear only before var. Slashes are required.

E[XIT]

causes termination of Interactive PMD and a return to the program if a BREAK keyin or call to FTNPMD caused the dump.

P29 [Batch Use]
Page 5 Line 30

Batch use:

To cause a symbolic PMD at the end of execution use an F-option on the @XQT card as well. This causes the commands DUMP ! and EXIT to occur if PMD is initiated.

P30 [Example]
Page 6 Line 1

FTN INTERACTIVE PMD EXAMPLE:

FTN Source code:

```
REAL R(5),A,B,C
DATA R/-3.0,-1.0,0.0,4Hdata,30.5/
COMMON A,B,C
A = 5.0
B = 10.
CALL SUB (R)
C = 15.
PRINT *,A,B,C
STOP
END

SUBROUTINE SUB (X)
REAL X(5),R,S,T
```

```
      COMMON R,S,T
      X(2) = 99.Ø
      CALL FTNPMD
      R = X(5)
      RETURN
      END
```

Resulting execution: (user commands in lower case)

```
*****  ENTER FTN PMD  *****
-dump,a r(4)/*/name$

R       /*      /NAME$
** FORTRAN DUMP ROUTINE **  ADDRESSES Ø51260 TO Ø51260
Ø51260   data
-d x/sub/name$

X       /SUB    /NAME$
** FORTRAN DUMP ROUTINE **  ADDRESSES Ø51255 TO Ø51261
Ø51255   -.30000000+Ø01 .99000000+Ø02   .11039264-Ø18
Ø51261    .30500000+Ø02
-dump r/sub/name$

R       /SUB    /NAME$
** FORTRAN DUMP ROUTINE **  ADDRESSES Ø51252 TO Ø51252
Ø51252    .50000000+Ø01
-d b//name$

B       /*      /NAME$
** FORTRAN DUMP ROUTINE **  ADDRESSES Ø51253 TO Ø51253
Ø51253    .10000000+Ø02
-exit

*****  EXIT FTN PMD *****
 30.500000      10.000000      15.000000
```


P32 [Title]
Page 7 Line 1

Internal Subprograms

P33 [General Description]
Page 7 Line 2

Internal subprograms are a newly-implemented feature of Ascii Fortran. The rules for internal subprograms regarding coding, syntax, and name scoping are the same as for Fortran V (cf. Fortran V - Compiler Reference Manual, section 4.8) The addition of this feature means you must be sure to put END cards where you intend them. Since multiple external subprograms can occur within a single element of a program file or a card deck, omitting an END statement can spell the difference between an internal and an external subprogram, resulting in very different executions after compilation. The compiler will signal no more warning than a eight printer line eject prior to the first line in the listing of an external subprogram included in a multiple program unit. This does not occur before an internal subprogram.

P34 [Example]
Page 7 Line 18

EXAMPLE LISTING:

```
@FTN,IS
FTN 6R1Q2-12/16/76-03:49
          1.   C     ** MAIN PROGRAM ****
00001     2.         INTEGER INDEX
00002     3.         DO 5 INDEX = 1,1Ø
00003     4.         CALL SQUARE
00004     5.    5    PRINT*,INDEX,'! = ',FACT(INDEX)
00005     6.         STOP
00006     7.         SUBROUTINE SQUARE
```

```
          8.   C     ** INTERNAL SQUARE ****
00007     9.         PRINT*,INDEX,'**2=',INDEX*INDEX
         10.   C        * SAME INDEX AS ABOVE LOOP *
00008    11.         RETURN
00009    12.         END



00010    13.         FUNCTION FACT(N)
         14.   C     ** EXTERNAL FACT ****
00011    15.         FACT=1
00012    16.         DO 5 INDEX = 2,N
00013    17.    5       FACT = FACT * INDEX
         18.   C        * LOCAL INDEX IN THIS LOOP *
00014    19.         RETURN
00015    20.         END

END FTN 56 IBANK 52 DBANK
```

P36 [Title]
Page 8 Line 1

Fortran V Interface Routines

P37 [Entry Points]
Page 8 Line 2

There are seven entry points in the FTN library to allow FTN programs to call Fortran V subprograms. The entry points are:

FN5$	to call subroutines
RFN5$	to reference REAL functions
DFN5$	to reference DOUBLE PRECISION functions
CFN5$	to reference COMPLEX functions

DCFN5$	to reference DOUBLE COMPLEX functions
NFN5$	to reference INTEGER functions
LFN5$	to reference LOGICAL functions

P38 [Calling Sequence]
Page 8 Line 12

Any Fortran V routines must be declared EXTERNAL in the calling Ascii Fortran module. The call and references should resemble:

```
     CALL FN5$ (buffer,subroutine,arg1,...,argn)
or
     ...xFN5$ (buffer,function,arg1,...,argn)...
```

where x is C,DC,N,R,L or D and buffer is an array of dimension at least n+4. The same buffer may be used for any call or reference independent of n or the external routine as long as it is large enough. The sequence arg1,...,argn is the argument list expected by the named subprogram.

P39 [Example]
Page 8 Line 24

EXAMPLE:

```
          DIMENSION CALL(12),VECTOR(100)
          EXTERNAL ursort,timset,timget
            .
            .
            .
     COMMENT - use Fortran V, MACC utility routines
          CALL FN5$(CALL,timset,0)
          CALL FN5$(CALL,ursort,0,100,VECTOR,D1,D2,0,0)
          LAPSE = RFN5$(CALL,timget,0)
            .
            .
```

A warning will be issued for the second CALL on FN5$ by the compiler due to the inconsistency in number of arguments, but this may be ignored.

P42 [Title]
Page 9 Line 1

Additional and Enhanced CHECKOUT Commands

P43 [General Description]
Page 9 Line 2

The commands described here are enhancements of existing commands or are newly implemented. Operation of CHECKOUT debugging mode and the rest of the available commands are described in the Fortran (Ascii) PRM. In the command formats given, fields within square brackets ([]) are optional.

P45 Call subprogram[(arg1,...,argn)]
Page 9 Line 8

CALL subprogram[(arg1,...,argn)]

This command calls the named FTN subprogram with the specified arguments. This allows you to test only a given subprogram without having to execute the entire FTN program. Arguments may be constants, variables, arrays, labels or entry points.

eg. C:CALL SUBX('Test',3,$99,ARRAYM,#ENTRYP)

P46 DUMP[,opt] [var][/unit]
Page 9 Line 16

DUMP[,opt] [var][/unit]

The scalar variable, array element, or array specified by var (or all the program unit's variables if omitted) are dumped in subprogram unit or main program if unit = * (or first unit if omitted) and are displayed according to their declared types or in octal format (with opt = O) or Ascii character format (with opt = A). One may not omit both var and unit.

P47 GO [nL]
Page 9 Line 25

GO [nL]

CHECKOUT debugging mode terminates and execution commences at the next executable statement if the nL field is omitted; otherwise the execution starts at the executable statement with label n.

P48 BREAK, CLEAR, SET, SETBP
Page 9 Line 30

BREAK, CLEAR, SET, SETBP

Variables and labels in these commands may be of the form loc[/unit] where loc is the variable or label and unit is * for the main program, n for the n-th BLOCK DATA program or the name of a subroutine. If loc is used alone, the default unit is either the first unit or the unit specified in a PROG command.

P49 SETBP[,opt] var[/unit]
Page 10 Line 1

SETBP[,opt] var[/unit]

This command sets a hardware breakpoint so that CHECKOUT debugging mode is re-entered whenever the designated var is set or referenced. Var may be an array element but not an array, and if it is a character variable, only the first storage location is affected. The 1110's programmable breakpoint register is used, so there may only be one SETBP command active at a time. Debug mode is re-entered at the beginning of the next executable statement after the specified variable has been set (opt = W), referenced (opt = R), or either set or referenced (no option). The breakpoint set in this manner can be cleared either by the CLEAR command or by another use of SETBP.

P50 WALKBACK
Page 10 Line 16

WALKBACK

This command produces a step-by-step trace of subprogram references that occur during CHECKOUT program execution. The starting point is the subprogram that was executing before debug mode was entered. The end point is the main program.

P51 Command Abbreviations
Page 10 Line 22

Command Abbreviations

All debug commands may be abbreviated to the first letter with the following exceptions: SAVE (SA), STEP (ST), CALL (CA), SETBP (SETB).

P53 [Title]
Page 11 Line 1

FTNR: Ascii Fortran Restart Processor

P54 [General Description]
Page 11 Line 2

A small separate processor, FTNR, is released by Univac with the Ascii Fortran system. This processor serves to restart previous CHECKOUT debugging sessions. It is called with the source input (SI) field of the @FTNR card containing a program file element which represents one of the SAVES from a previous FTN session. The processor signs on in a standard manner and goes interactive after reloading the program. Using FTNR can avoid recompilations of programs over several debugging sessions if the first CHECKOUT command after the compilation is SAVE and the file specified to hold the checkpointed executions is still available.

P55 [Example]
Page 11 Line 15

EXAMPLE:

```
@FTN,ISCZ PROG,SAVEFILE.PROG1
   .
   .   [checkout program]
   .
@EOF
   .
   .   [data and checkout commands]
   .
C:SAVE 6
   .
   .
@FTNR SAVEFILE.PROG1
FTNR 6R1 72R1U1
ENTERING USER PROGRAM : PROG1
C:RESTORE 6
```

P56 Additional Comments
Page 11 Line 31

All CHECKOUT commands are available in FTNR. The same level of FTN and FTNR must be used. This is true of the RESTORE command also. The same level of FTN/FTNR must have done the corresponding SAVE. Note that the file expressed in the relocatable output (RO) field (SI if omitted) on the FTN checkout processor card is the file used to save the state of the started FTN program. Any I/O files used by the CHECKOUT program are not saved.

P58 [Title]
Page 12 Line 1

Abnormal FUNCTION Returns

P59 [General Description]
Page 12 Line 2

The RETURN i feature is now implemented for abnormal FUNCTION returns in the same manner as for SUBROUTINE returns.

P60 [Example]
Page 12 Line 5

EXAMPLE:

```
      .
      .
   ANSWER = 10.0E+3 - SQRT(PHI(BETA,KAPPA,$90))
      .
      .
90 PRINT *,'PHI negative to SQRT'
      .
      .
   END
   REAL FUNCTION PHI(A,B,*)
      .
      .
   IF(PHI.LT.0.0) RETURN 1
   RETURN
   END
```

Should function PHI compute a negative value, a branch to statement 90 will avoid the argument out of range to SQRT.

P62 [Title]
Page 12 Line 24

ENCODE / DECODE Extensions

P63 [General Description]
Page 12 Line 25

[,ERR=n] is now an optional last clause in both the ENCODE and DECODE statements of Ascii Fortran. The n must be an executable statement number in the program unit and control will transfer to that executable statement if an error occurs in the execution of the ENCODE or DECODE statement.

P64 [Example]
Page 12 Line 31

EXAMPLE:

```
      ENCODE(80,11,RESULT,LENGTH,ERR=99)A,B,C,...
   11 FORMAT(...)
        .
        .
   99 PRINT *,'ENCODE Error, FORMAT 11.'
        .
        .
```


P66 [Title]
Page 13 Line 1

Cost Warnings to FTN Users

P67 [General Description]
Page 13 Line 2

There are several very useful features of Ascii Fortran that are rather expensive to use on the Univac 1110. Several important examples follow.

P69 Direct Access I/O
Page 13 Line 6

* Direct Access I/O. When a DEFINE FILE statement is encountered that describes a direct access I/O file different from the file it is attached to, the file will be skeletonized. This means empty records are written to fill the file to its maximum size and can accrue substantial I/O costs.

P70 F-option Collection
Page 13 Line 13

* F-option Collection. The use of the F-option on Ascii Fortran compilations can result in collected absolutes up to twice the size of absolutes collected from the same compilations without the F-option. Collection cost can increase three to four-fold at the same time.

P71 Many large subroutines
Page 13 Line 19

* Many large subroutines. While the Ascii Fortran compiler is capable of compiling many subprograms in a single element, there is a point at which it becomes less expensive to do several small compilations than one large one. At approximately 1500 lines of Fortran code, mass storage files are required to save results due to main memory compiler tables becoming full. For example, it is better to do two 1500 line compilations than one 3000 line compilation .

P72 Punch Restriction [Limitation]
Page 13 Line 29

Punch Restriction

Output files created by Ascii Fortran are marked as Ascii encoded data sets. This includes punch files. At MACC, Ascii SDF files can only be translated to card punch codes on punch symbiont

CP2. Punch should be @EDIT'd to Fieldata or @SYM'd to CP2.

P74 [Title]
Page 14 Line 1

Utility Routines

P75 [General Description]
Page 14 Line 2

N$ARGS(<NPARMS>,<NAME>,$<N>) -- Argument Check

This routine may be used within an external function or subroutine to check that a subprogram was called with the correct number of parameters. N$ARGS may be used as a subroutine or a logical or integer function. <NPARMS> is the number of parameters that should have been used in the call, <NAME> is a character string name of the checked subprogram, and <N> is a statement number labelling the first statement of the checked subprogram. Zero or .FALSE. is returned as the value of the function when an improper number of arguments was used in the call. As either a subprogram or function, an error message is printed on the occurrence of an improper call.

P76 [Example]
Page 14 Line 18

Sample usage:

```
      SUBROUTINE SUBX (A,B,C,*)
      LOGICAL N$ARGS
1     IF( .NOT.N$ARGS(4,'SUBX',$1) )RETURN
```

The passage-dependent network is shown below. The nodes have arbitrarily been assigned the identifiers N1, N2, etc. Most nodes are category nodes. Nodes marked with an asterisk are co-occurrence nodes. Labels are shown in brackets. Unlabelled nodes have been given descriptive names. Under each node is a list of its immediate descendants within the passage-dependent network and the passages in the passage tree to which it points. The table-of-contents entries have been encoded as cross-references.

N1 [Cross-References]
N4, N39

N2 [Referenced Passage]
N7, N9, N11, N13, N15, N17, N19, N21, N23, N25, N27, N29, N31, N35, N37

N3 [Referencing Passage]
N32, N38

N4 [Internal Reference]
N5, N33

N5 [Table of Contents Entries]
N6, N8, N10, N12, N14, N16, N18, N20, N22, N24, N26, N28, N30

N6 References to P7 (FTN Compiler Option Changes)
N7, N32

N7 Location of P7
P7

N8 References to P14 (Collection of FTN Programs)
N9, N32

N9 Location of P14
P14

N10 References to P25 (Interactive Postmortem Dump)
N11, N32

N11 Location of P25
P25

N12 References to P22 (FTN Walkback Facility)
N13, N32

N13 Location of P22
P22

N14 References to P31 (Internal Subprograms)
N15, N32

N15 Location of P31
P31

N16 References to P35 (Fortran V Interface Routines)
N17, N32

N17 Location of P35
P35

N18 References to P41 (Additional/Enhanced CHECKOUT Commands)
N19, N32

N19 Location of P41
P41

N20 References to P52 (FTNR: Ascii Fortran Restart Processor)
N21, N32

N21 Location of P52
P52

N22 References to P57 (Abnormal FUNCTION Returns)
N23, N32

N23 Location of P57
P57

N24 References to P61 (ENCODE/DECODE Extensions)
N25, N32

N25 Location of P61
P61

N26 References to P65 (Cost Warnings to FTN Users)
N27, N32

N27 Location of P65
P65

N28 References to P72 (Punch Restriction)
N29, N32

N29 Location of P72
P72

N30 References to P73 (Utility Routines)
N31, N32

N31 Location of P73
P73

N32# Location of Table-of-Contents
P5

N33 References by Page
N34, N36

N34 References to P15 (FTN Walkback and Interactive Postmortem Dump)
N35, N38

N35 Location of P15
P15

N36 References to P70 (Cost of F-option Collection)
N37, N38

N37 Location of P70
P70

N38# Passages Referenceing P15 and P70
P10

N39 [External Reference]
N40, N43

N40 to Ascii Fortran PRM
N41, N42

N41 supplemented by this document
P3, P4

N42 for specific information
P43

N43 to Fortran V - Compiler Reference Manual, section 4.8
P33

N44 ASCII Fortran
N50, N73, N77, N84, N85, N86, N95, N97, N98

N45 [Topic]
N44, N47, N74, N76, N80, N81, N86, N88, N89, N91, N92, N93, N97, N98

N46 [Mention]
N64, N72, N77, N82, N85, N95

N47 [Options]
N48, N49

N48 [Program]
N50, N71

N49 Individual Options
N52, N53, N54, N55, N56, N57, N66, N68

N50 Compiler Options
N51, N64

N51 [System Change]
N58, N59, N60, N61, N62, N63

N52 E Option
N59, N72

N53 F Option
N60, N70

N54 T Option
N61

N55 X Option
N62

N56 Y Option
N63

N57 D Option
N65

N58 Compiler Option Changes
P7

N59 Description of Compiler E Option
P9

N60 Description of Compiler F Option
P10

N61 Description of Compiler T Option
P11

N62 Description of Compiler X Option
P12

N63 Description of Compiler Y Option
P13

N64 Mention of Compiler Options
N65, N67, N69, N70

N65 Mention of D Option
P13

N66 C Option
N67

N67 Mention of Compiler C Option
P14

N68 O Option
N70

N69 Mention of Compiler O Option
P14

N70 Mention of Compiler F Option
P17, P70

N71 Collector Options
N72

N72 Mention of Collector E Option
P14

N73 Interactive Postmortem Dump
N74, N75, N76

N74 When Interactive Postmortem Dump Occurs
P19 P21

Appendix D

This appendix shows the passage tree and the passage-dependent network of a strep for the LEXICO Maintenance Guide, along with a segmentation of the text. The passage tree is shown below. The passages have arbitrarily been assigned the identifiers P1, P2, etc. Names and labels for each passage are listed after these P numbers; labels are enclosed in square brackets.

P1 LEXICO Maintenance Guide
- P2 [Title Page]
- P3 [Body]
  - P4 1. [Introduction]
  - P5 2. Command Language Features
    - P6 [Title]
    - P7 [Subsections]
      - P8 2.1 ROUTE
      - P9 2.2 [Options]
      - P10 2.3 QFILE
      - P11 2.4 GLOBAL
      - P12 2.5 PROJECT
      - P13 2.6 MESSAGES
      - P14 2.7 The Resolver
      - P15 2.8 START
      - P16 2.9 Resetting the Bad Collection Bit
  - P17 3. Options
    - P18 [Title]
    - P19 [Subsections]
      - P20 3.1 Parser Options
        - P21 [Introduction]
        - P22 List of Options
          - P23 A Option
          - P24 D Option
          - P25 E Option
          - P26 F Option
          - P27 H Option
          - P28 I Option
          - P29 L Option
          - P30 M option
          - P31 N Option
          - P32 O Option
          - P33 P Option
          - P34 Q Option
          - P35 R Option
          - P36 S Option
          - P37 T Option
          - P38 U Option
          - P39 W Option
          - P40 X Option
      - P41 3.2 Adder and Concorder Options
      - P42 3.3 LISTTYPES, RESPELL, LOOKUP and SLIPS
      - P43 3.4 Listing Rules
      - P44 3.5 Resolver Options
        - P45 [Introduction]
        - P46 Options List
          - P47 C Option
          - P48 D Option
          - P49 F Option
          - P50 N option
          - P51 O Option
          - P52 S Option
      - P53 3.6 The Message Processor
      - P54 3.7 STATISTICS
- P55 4. [Files]
  - P56 [Title]
  - P57 [Subsections]
    - P58 4.1 System Defaults
    - P59 4.2 The Log File
    - P60 4.3 The Statistics File
- P61 5. Supporting Programs
  - P62 [Title]
  - P63 [Subsections]
    - P64 5.1 Changing Array Sizes in the Resolver
      - P65 [Title]
      - P66 What to Change
      - P67 How to Make the Changes
    - P68 5.2 Statistics
      - P69 [Title]
      - P70 Printing Statistics
      - P71 [Options]
      - P72 Data Cards
      - P73 Packet Types

```
        P74   [Introduction]
        P75   List of Packet Types
            P76   ADD
            P77   CONCORD
            P78   ADDCONCORD
            P79   RESPELL
            P80   LOOKUP
            P81   SLIPS
            P82   ORB EXPAND (NO
                  COPY)
            P83   ORB EXPAND (WITH
                  COPY)
            P84   TEXT EXPAND
            P85   TIDTAB EXPAND
            P86   CREATE BACKUP
            P87   RESTORE COLLECTION
            P88   LIST TYPES
            P89   LIST TYPES REVERSED
            P90   LIST TYPES BY
                  FREQUENCY
            P91   LIST SR
            P92   LIST ALL BTR
            P93   LIST ALL BTR FOR
            P94   LIST TEXT
            P95   PACK BTR
            P96   PACK TEXTS
            P97   PACK CONCORDANCES
            P98   CREATE HASH TABLE
            P99   EXPAND HASH TABLE
            P100  CLEANUP
            P101  EDIT
            P102  LEXICO (SIGN-ON)
            P103  LEXICO (SIGN-OFF)
            P104  COPY BTR FROM
P105  5.3 FDUMP
P106  5.4 MAIL
    P107  [Title]
    P108  Sending Mail
    P109  Addresses
P110  5.5 Dumping Hash Files
```

The text segments associated with each terminal passage are shown below. Passages are identified with the

numberings given to nodes in the passage tree as well as by page and line references to the text.

When a section is not subdivided into several passages, any section heading is included as part of the single passage comprising the section. When the material in one section is segmented into several passages, the section heading is placed into a passage by itself. Some information in this text (e.g., P22, P46, P75) is presented as a list of items in a tabular form. In order to show the interaction of concepts identified in the text-based network, each entry in these lists has been treated as a separate passage. In an actual implementation of some application of streps, tables would probably be treated as a special case so that this material could be left unsegmented.

P2 [Title Page]
Page Title Page Line 1

LEXICO MAINTENANCE GUIDE

Nathan Relles
Lynne A. Price

Computer Sciences Department
University of Wisconsin
February, 1977

P4 1. [Introduction]
Page 1 Line 1

1. Introduction

This document partially describes maintenance of the LEXICO system. It is a reference manual for the programmer who is familiar with the basic components of the system and forms only a small portion of the desirable internal documentation. Included are command language capabilities, options, debugging features, auxiliary files and supporting programs.

P6 [Title]
Page 2 Line 1

2. Command Language Features

P8 2.1 ROUTE
Page 2 Line 2

2.1 ROUTE

The commands

```
ROUTE r ;
ROUTE r n ;
ROUTE r m - n ;
ROUTE r charst;
```

may be used to transfer to a route r in QUEENB (after setting NUM, NUMM and NUMN, or SCHSEQ and IS). These statements may appear in any block. They have two uses; they may be used to test a new command that has not yet been resolved into the grammar and they may be used to request system functions that have no corresponding command language statement. Route numbers for these system statements are all greater than 999. The special command

```
ROUTE 1000;
```

causes a display of the system route numbers and the function of each.

P9 2.2 [Options]
Page 2 Line 19

2.2 Options

Parser options (which are listed in Section 3.1) may be set on the control statement or with either of the commands

```
ROUTE 1005;
OPTION olist;
```

Both commands may be entered in any block. The former causes a display of all available options followed by prompts for the options to be changed. In the latter command, olist is a list of letters and numbers indicating options whose on/off flags are to be reversed. Reserved words appearing within olist must be enclosed in quotes. d and s are reserved throughout the system and t is reserved in EDIT blocks.

P10 2.3 QFILE
Page 3 Line 5

2.3 QFILE

The command

```
ROUTE 1007;
```

may be used in any block to inspect or change any assigned file. The system will prompt for file name, location, number of words, etc..

P11 2.4 GLOBAL
Page 3 Line 11

2.4 GLOBAL

The command

```
ROUTE 1006;
```

may be used in any text-specific block to inspect or change a text header; it may be used to inspect or change the collection header elsewhere. Changes may be made in core, to the collection file, or both. The system will prompt for all necessary information.

P12 2.5 PROJECT
Page 3 Line 19

2.5 PROJECT

The task command

```
ROUTE 1004 'proj';
```

may be used to work with a collection defined under a project other than the one to which the current run is being charged. The parameter is a character string--the quotes are necessary.

P13 2.6 MESSAGES
Page 4 Line 3

2.6 MESSAGES

The task command

ROUTE 1003;

starts a job that runs the message processor. The system prompts for the qualifiers for PARSER, LIB, and UAIDS. It also asks whether or not a listing should be generated. The started run does not create the UAIDS file.

P14 2.7 The Resolver
Page 4 Line 10

2.7 The Resolver

The task command

ROUTE 1002;

causes prompts for the qualifiers for LIB and PARSER and for desired options and then starts a run to resolve the grammar. The result is a relocatable element PARSER.GRAMMAR which takes effect when LEXICO is remapped.

P15 2.8 START
Page 4 Line 17

2.8 START

In response to the task command

ROUTE 1001;

the system sets the R option (unless it is already on), asks if an off-line backup should be created, and then starts a run.

P16 2.9 Resetting the Bad Collection Bit
Page 5 Line 1

2.9 Resetting the Bad Collection Bit

The command

ROUTE 1008;

causes the bad collection bit of the current collection to be cleared (both in core and on the file). It may be entered in any block but should be used with extreme caution. If a problem occurs when changes made to basetype rules may not have been completed on the hash file, it is preferable to restore the collection and repeat any intervening processes.

P18 [Title]
Page 6 Line 1

3. Options

P21 [Introduction]
Page 6 Line 2

3.1 Parser Options

Currently defined options in the parser are

P23 A Option
Page 6 Line 4

A (6)--display route on each call to QUEENB

P24 D Option
Page 6 Line 5

D (9)--display images from DYNAMO

P25 E Option
Page 6 Line 6

E (10)--display runstream images

P26 F Option
Page 6 Line 7

F (11)--UIOPAK (UOPEN, UREAD, UWRITE, UCLOSE) trace

P27 H Option
Page 6 Line 8

H (13)--UIOPAKH trace (hash file)

P28 I Option
Page 6 Line 9

I (14)--input buffer and character count from UGIN and UGINA6

P29 L Option
Page 6 Line 11

L (17)--create master log file (see Section 4.2)

P30 M Option
Page 6 Line 12

M (18)--display erroneous uaids packets

P31 N Option
Page 6 Line 13

N (19)--do not write log file (see Section 4.2)

P32 O Option
Page 6 Line 14

O (20)--UORBIN, UORBOT, ORBpak expansion trace

P33 P Option
Page 6 Line 15

P (21)--parser trace

P34 Q Option
Page 6 Line 16

Q (22)--use developmental files: prompt for qualifier for UAIDS at initiation and for qualifier in processor calls in started runs

P35 R Option
Page 6 Line 19

R (23)--modify started runs: allow change of run limits, insertion of card images after the RUN statement and at the end of the runstream, and prompt for qualifier in processor calls

P36 S Option
Page 6 Line 23

S (24)--UFD2NF trace

P37 T Option
Page 6 Line 24

T (25)--EDIT trace

P38 U Option
Page 6 Line 25

U (26)--UIOPAKU trace (UAIDS)

P39 W Option
Page 6 Line 26

W (28)--stopword trace dump

P40 X Option
Page 6 Line 27

X (29)--display undefined packets

P41 3.2 Adder and Concorder Options
Page 6 Line 28

3.2 Adder and Concorder Options

The A (6) option causes tracing information to be printed during adding or concording. The X (29) option prevents the text from being stored in the collection on an ADD. The W (28) option suppresses generation of the printable concordance.

P42 3.3 LISTTYPES, RESPELL, LOOKUP and SLIPS
Page 7 Line 1

3.3 LISTTYPES, RESPELL, LOOKUP and SLIPS

The D (9), F (11), and O (20) options have the same purpose in all ORBfile programs as in the parser. LOOKUP and SLIPS also use the H (13) option. SLIPS uses the C (8) option as a trace on reading the concordance file, and S (24; slips), B (7; base concordance), and T (25; slips file) to indicate output options.

P43 3.4 Listing Rules
Page 7 Line 8

3.4 Listing Rules

The F (11) option is used in listing spelling and basetype rules. The D (9) and H (13) options are used listing basetype rules. All three are used as in the parser.

P45 [Introduction]
Page 7 Line 12

3.5 Resolver Options

Options in the resolver are

P47 C Option
Page 7 Line 14

C (8)--list terminal vocabulary

P48 D Option
Page 7 Line 15

D (9)--debug trace

P49 F Option
Page 7 Line 16

F (11)--print finite state automaton

P50 N option
Page 7 Line 17

N(19)--list new grammar(productions sorted by length)

P51 O Option
Page 7 Line 18

O (20)--list grammar in original form

P52 S Option
Page 7 Line 19

S (24)--list grammar, vocabulary, and ROUTER array

P53 3.6 The Message Processor
Page 7 Line 20

3.6 The Message Processor

The S (24) option on the message processor causes a source listing.

P54 3.7 STATISTICS
Page 8 Line 1

3.7 STATISTICS

The P (21) option on the statistics program suppresses printing of packets from runs under project 9812. The D (9) option causes only packets from selected dates to be printed.

P56 [Title]
Page 9 Line 1

4. Files

P58 4.1 System Defaults
Page 9 Line 2

4.1 System Defaults

The system default values for all parameters are stored in a one-file collection called DEFAULTS under project 5603. Any of these values may be changed by entering appropriate commands in an UPDATE block. A defaults file must exist if any other collection is to be created. Of course, a new defaults file may be created in a

CREATE block. If this is done, the resulting hash file should be deleted.

P59 4.2 The Log File
Page 9 Line 10

4.2 The Log File

A log file, containing most system messages and all user input read by UGIN (or UGINA6), will be catalogued and saved for every run of LEXICO initiated without the N option whenever a master log file exists. A master log file will be created and initialized, but not saved, whenever a run is initiated with the L option on and the N option off, unless there is an existing master log. The master log file, called 5603*LOG, contains its length in words in the first location. All following locations contain names of run logs in two-word packets. If no log has been catalogued, a temporary log may be created on unit 12 by setting option N equal to 0 after initialization.

P60 4.3 The Statistics File
Page 10 Line 1

4.3 The Statistics File

Various parts of the LEXICO system record their use on a file called LXCO*STATS//KEY. This file is created when needed but not saved.

P62 [Title]
Page 11 Line 1

5. Supporting Programs

P65 [Title]
Page 11 Line 2

5.1 Changing Array Sizes in the Resolver

P66 What to Change
Page 11 Line 3

The following parameters, shown with their current values, are used in the resolver and parser to determine sizes of several arrays:

PROZ1:	310	maximum number of productions
PROZ2:	6	maximum length of a production

```
CLWORZ: 175     maximum number of user keywords
                (e.g., S, SH, SHOW)
CLWRZ1:  12     maximum length of keywords
```

P67 How to Make the Changes
Page 11 Line 11

To change any of these values the following steps should be taken

1) change value in LXCO*LIB.RESOLV
2) change value in LXCO*LIB.PROXY
3) @PDP,FIX LXCO*LIB.PROCS (@ADD LXCO*LIB.PROXY)
4) compile LXCO*LIB.RESOLV
5) @PREP LXCO*LIB. (optionally @PACK LXCO*LIB.)
6) @MAP LXCO*LIB.RESOLVER,LXCO*ABS.
7) run resolver
8) compile LXCO*PARSER.PARSER
   LXCO*PARSER.PINIT2
   LXCO*PARSER.PNXTCH
   LXCO*PARSER.QUEENB
9) @MAP LXCO*PARSER.LEXICO,LE*ICO.

P69 [Title]
Page 11 Line 25

5.2 Statistics

P70 Printing Statistics
Page 11 Line 26

To print the statistics file, use

```
@ASG,AX LXCO*STATS.
@ASG,T STATS.
@COPY LXCO*STATS.,STATS.
@FREE LXCO*STATS.
@LXCO*ABS.STATISTICS,options
  fdate ldate (if D option set)
  optional data cards
@
```

P71 [Options]
Page 12 Line 1

If the D option is set the first data card should contain in (2A6) the first date and last date for which statistics should be printed. If the P option is on, packets for jobs run under 9812 will not be printed.

P72 Data Cards
Page 12 Line 4

The optional data cards specify (in free format) the numbers of the desired packet types. If no data cards are present, the entire file will be dumped.

P74 [Introduction]
Page 12 Line 7

The numbers of currently defined packet types are

P76 ADD
Page 12 Line 8

1 ADD

P77 CONCORD
Page 12 Line 9

2 CONCORD

P78 ADDCONCORD
Page 12 Line 10

3 ADDCONCORD

P79 RESPELL
Page 12 Line 11

4 RESPELL

P80 LOOKUP
Page 12 Line 12

5 LOOKUP

P81 SLIPS
Page 12 Line 13

6 SLIPS

P82 ORB EXPAND (NO COPY)
Page 12 Line 14

7 ORB EXPAND (NO COPY)

P83 ORB EXPAND (WITH COPY)
Page 12 Line 15

8 ORB EXPAND (WITH COPY)

P84 TEXT EXPAND
Page 12 Line 16

9 TEXT EXPAND

P85 TIDTAB EXPAND
Page 12 Line 17

10 TIDTAB EXPAND

P86 CREATE BACKUP
Page 12 Line 18

11 CREATE BACKUP

P87 RESTORE COLLECTION
Page 12 Line 19

12 RESTORE COLLECTION

P88 LIST TYPES
Page 12 Line 20

13 LIST TYPES

P89 LIST TYPES REVERSED
Page 12 Line 21

14 LIST TYPES REVERSED

P90 LIST TYPES BY FREQUENCY
Page 12 Line 22

15 LIST TYPES BY FREQUENCY

P91 LIST SR
Page 12 Line 23

16 LIST SR

P92 LIST ALL BTR
Page 12 Line 24

17 LIST ALL BTR

P93 LIST ALL BTR FOR
Page 12 Line 25

18 LIST ALL BTR FOR

P94 LIST TEXT
Page 12 Line 26

19 LIST TEXT

P95 PACK BTR
Page 12 Line 27

20 PACK BTR

P96 PACK TEXTS
Page 12 Line 28

21 PACK TEXTS

P97 PACK CONCORDANCES
Page 12 Line 29

22 PACK CONCORDANCES

P98 CREATE HASH TABLE
Page 12 Line 30

23 CREATE HASH TABLE

P99 EXPAND HASH TABLE
Page 12 Line 31

24 EXPAND HASH TABLE

P100 CLEANUP
Page 12 Line 32

25 CLEANUP

P101 EDIT
Page 12 Line 33

26 EDIT

P102 LEXICO (SIGN-ON)
Page 12 Line 34

27 LEXICO (SIGN-ON)

P103 LEXICO (SIGN-OFF)
Page 12 Line 35

28 LEXICO (SIGN-OFF)

P104 COPY BTR FROM
Page 12 Line 36

29 COPY BTR FROM

P105 5.3 FDUMP
Page 13 Line 1

5.3 FDUMP

To inspect or change any assigned file, enter

@LXCO*ABS.FDUMP

The system will prompt for the file name, address and number of words.

P107 [Title]
Page 13 Line 6

5.4 MAIL

P108 Sending Mail
Page 13 Line 7

A message may be written for any user to receive when he signs on to the parser. To send such a message, first verify that the mail file (5603*MAIL) exists and has been initialized (with @LXCO*ABS.CLEARMAIL). Then enter

@LXCO*ABS.MAIL

The system will prompt for the user number and message.

P109 Addresses
Page 13 Line 13

The numbers of a select group of LEXICO users are

NR	3934231642
NR	9312
LP	5687266949
RLV	3592886141
RUSS	40155
ASHLEY	92471

P110 5.5 Dumping Hash Files
Page 13 Line 20

5.5 Dumping Hash Files

To dump all or part of a hash file in a readable format use

```
@ASG,AX proj*cn4
@LXCO*ABS.DUMPHASHFILE
```

where proj is the project number and cn is the collection name. The system will prompt for the file name (cn4). It will then ask if the entire letter table should be output. If the response is y the letter table is displayed or printed for every character which has an undeleted hash table. If there is any other response, the system will prompt for individual characters for which the letter table should be produced. These should be entered in (1X,A1) format, terminated by an @EOF. The system will then ask if all the hash tables should be output. Again a y

response indicates that they should and anything else initiates prompting for indivdual hash tables in (1X,A1). If there is no undeleted hash table for any requested letter, no output will be produced either for the letter table or for the hash table. Since this program can produce large listings, it should be used on-line with caution.

The passage-dependent network is shown below. The nodes have arbitrarily been assigned the identifiers N1, N2, etc. Most nodes are category nodes. Nodes marked with an asterisk are co-occurrence nodes. Functions are shown in brackets. Unlabelled nodes have been given descriptive names. Under each node is a list of its immediate descendants within the passage-dependent network and the passages in the passage tree to which it points.

Implicit cross-references have been identified from the introduction to various other parts of the manual. The reader may wish to select a few of the more important concepts (e.g., N55, the program called "the Parser"; N138, "Options"; and N88, "Files") and trace their descendants through the network, looking for the intersections of paths from these nodes.

N1 [Topic]
N79, N80, N81, N82, N83, N84, N86, N88, N122, N123, N124, N126, N133, N134, N136, N142, N143, N145, N168, N169, N170, N171, N172, N173, N174, N175, N176, N177, N178, N179, N180, N181, N182, N183, N184, N185, N186, N187, N189, N205, N209, N216, N217, N224, N255, N260

N2 [Co-topic]
N87, N89, N90, N113, N115, N116, N117, N118, N119, N127, N128, N129, N135, N137, N138, N139, N140, N190, N191, N192, N193, N198, N199, N200, N201, N202, N203, N205, N206, N207, N208, N218, N219, N257, N259

N3 [Mention]
N8, N40, N43, N46, N50, N110, N111, N112, N147, N175, N178, N220, N221

N4 [Cross-References]
N7, N49

N5 [Referencing Passage]
N9, N39, N42, N47, N48, N52, N55

N6 [Referenced Passage]
N11, N13, N16, N18, N20, N22, N24, N26, N28, N31, N33, N35, N38, N41, N44, N47, N51, N54

N7 [Implicit References]
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