Memory Representation and Retrieval for Editorial Comprehension[1]

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Abstract

In this paper, we present a process model of editorial comprehension, representation, and retrieval. Editorial comprehension involves building an argument graph organized by abstract argument strategies which are represented declaratively as *argument units*. Issues include: (a) organizing and indexing goals, plans, events, states, beliefs, and belief justifications instantiated during comprehension of editorial arguments; and (b) retrieving information from conceptual representations of editorial arguments. This process model of reasoning and argument comprehension is currently being implemented in OpEd (Alvarado et al., 1985a), a computer system that reads short politico-economic editorials and answers questions about them.

1. Introduction

Understanding a newspaper or magazine editorial requires building internal conceptual representations of editorial arguments that include goals, plans, events, states, beliefs, and belief justifications. This involves applying linguistic knowledge (e.g., knowledge of lexical items that refer to domain-specific objects, beliefs, causality, etc.) as well as recognizing and instantiating a disparate number of knowledge structures, such as: goals and plans (Schank and Abelson, 1977; Wilensky, 1983); ideologies (Carbonell, 1981); affective reactions (Dyer, 1983); belief and belief justifications (Alvarado et al., 1985a; Flowers, 1985; Flowers et al., 1982; Toulmin, 1979); and argument units (Alvarado et al., 1985a, b). For example, consider the following editorial excerpt from (Thurow, 1983):

ED-TARIFFS

> The Reagan administration argues that America does not need an industrial policy since all government has to do to guarantee economic success under capitalism is keep out of the way. Yet the Reagan administration has just ... increase[d] tariffs on large motorcycles from 4.4 percent to 49.4 percent.

Understanding ED-TARIFFS requires realizing that: (a) the Reagan administration's belief that no industrial policy is needed is supported by its laissez-faire belief; (b) tariffs are PROTECTION-PLANS used by the government to control imports; and (c) the Reagan administration's behavior is hypocritical since increasing tariffs go against a laissez-faire policy.

The memory representation of an editorial must also include indexing structures and access links which are created during editorial comprehension and later used by search and retrieval processes during question answering. For instance, answering the following question about ED-TARIFFS:

Q: Does America need an industrial policy?

A: The Reagan Administration believes that America does not need an industrial policy.

requires: (a) indexing structures from general and specific plans to their instantiations and access links between instantiated PLANS and their associated BELIEFS; and (b) retrieval functions that take PLANS and GOALS as input and retrieve appropriate BELIEFS.

In this paper, we discuss memory representation and memory retrieval techniques which are currently being implemented in OpEd (Opinions to/from the Editor) (Alvarado et al., 1985a), a computer program that reads and answers questions about short-politico economic editorials. OpEd is an integrated natural understanding system, i.e., it uses the same conceptual parser during editorial comprehension and question answering. OpEd's design is based on the demon-based conceptual parser implemented in BORIS (Dyer, 1983) and the question answering theory developed by Dyer and Lehnert (1982) as an extension of previous work by Lehnert (1978). The examples presented in this paper will be taken from the following editorial segment by Milton Friedman (1982):

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Recent protectionist measures by the Reagan administration have disappointed us ... [voluntary] limits on Japanese exports of automobiles ... are ... bad for the nation ... Far from saving jobs, the limitations on imports will cost jobs. If we import less, foreign countries will earn fewer dollars. They will have less to expend on U.S. exports. The result will be fewer jobs in export industries.

2. Conceptual Representation of an Editorial

The memory representation of an editorial forms a graph of conceptual constructs instantiated during editorial comprehension. Within this graph, instantiated constructs are connected by memory links that indicate how they relate to one another, i.e., the links indicate knowledge dependencies such as: causal dependencies, support/attack relationships, containment relationships, and indexing relationships.

Five major elements compose the conceptual graph of an editorial:

1) Instantiations of: domain-specific objects (e.g., nations), goals, plans, events, states, affective reactions, and participants in editorial arguments (e.g., the editorial writer and his implicit opponents).
2) Instantiations of beliefs of participants in editorial arguments.
3) An *argument graph* (Birnbaum, 1982; Flowers et al., 1982) which includes all instantiated beliefs, belief relationships, and belief justifications involving the different participants in editorial arguments.
4) Instantiations of *argument units* which organize abstract knowledge about reasoning and argumentation.
5) Indexing structures which allow search and retrieval processes access to the argument graph.

In this section, we focus on beliefs, argument graphs, and argument units.

2.1. Beliefs

Computer comprehension of editorials is based on the capability of recognizing beliefs, belief supports, and belief attacks. Current text understanding programs are capable of reading stories involving stereotypic situations, goal and planning situations, and complex human interactions (Cullingford, 1978; DeJong, 1979; Dyer, 1983; Lebowitz, 1980; Wilensky, 1983). However, those programs cannot read editorials since they lack basic mechanisms for: (a) understanding and keeping track of beliefs and belief justifications, and (b) using world knowledge during reasoning comprehension.

Abelson (1979) has pointed out that even though belief systems share common ground with knowledge systems, beliefs can be set apart from structured knowledge. Beliefs are not goals, plans, events, or states, but rather predications about these structures and their relationships (Abelson, 1973). For example, the following predications can be distinguished:

Evaluative: Free-trade economists believe that protectionist measures are bad.

Judgemental: Free-trade economists believe that the U.S. should not renew voluntary quotas on Japanese exports of automobiles.

Causal: Free-trade economists believe that voluntary limits on Japanese exports of automobiles will cost jobs in the U.S..

Expectational: American auto makers believe that the Reagan administration will renew the voluntary quotas on Japanese exports of automobiles.

Factual: The Reagan administration believes that American auto makers have already returned to profitability.

Beliefs about Beliefs (Wilks and Bien, 1983): Western countries believe that Eastern countries believe that Western countries will launch a nuclear attack.

How are beliefs represented in OpEd? We consider that each belief consists of: (a) the holder of the belief; (b) belief contents; and (c) links that indicate whether the belief attacks, supports, or is supported by other beliefs. For example, Friedman's belief that voluntary limits on imports will cost jobs is represented as:

```
(BELIEF BELIEVER (FRIEDMAN0)
        CONTENT  (PROTECTION-PLAN0 --thwart--> P-JOB0))
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where FRIEDMAN0 refers to an instantiation of OpEd's knowledge about Friedman, PROTECTION-PLAN0 to an instantiation of protectionist plans, and P-JOB0 to an instantiation of the goal PRESERVE-JOB.

In general, contents of beliefs involve either: (a) a causal dependency; (b) a chain of causal dependencies; or (c) an evaluative component. Causal dependencies usually include intentional relationships between goals, plans, events, and states, such as: goal motivation, goal failure, goal achievement, goal suspension, event realization, plan intention, and plan enablement. These dependencies are represented by means of *intentional links* (I-links) (Dyer and Lehnert, 1982). Other non-intentional causal dependencies such as relationships between economic quantities (Riesbeck, 1983), are represented using a general causal link. For example, ED-JOBS contain the following causal dependencies:

Goal Failure: Executing the Reagan Administration's PROTECTION-PLAN (i.e., the limitations on imports) thwarts the goal PRESERVE-JOBS.

Goal Achievement: Executing the PROTECTION-PLAN will achieve the goal PRESERVE-JOBS.

Consequent State: Earning fewer dollars motivates having less resources to buy imports.

Beliefs which contain evaluative components (Abelson, 1979) refer to high level abstractions such as "X believes that Y is GOOD" and "X believes that Y is BAD" that indicate whether X leads to positive or negative outcomes (e.g., goal and expectation failures or achievements). We believe that "GOOD" and "BAD" are primitives which act as place holders, much like DO in Conceptual Dependency (CD) theory (Schank, 1973, 1975). For example, in the CD representation of "John killed Mary":

```
(LEAD-TO ANTECEDENT (DO ACTOR (JOHN))
         CONSEQUENT (STATE-CHANGE STATE (PHYS-STATE CHARACTER (MARY))
                                  FROM  ( > -10 )
                                  TO    ( < -10 ) ))
```

DO is a place holder for John's action which can later be filled if we hear the actual actions (e.g., "John strangled Mary to death"). Similarly, GOOD and BAD are place holders for unknown positive and negative outcomes. Thus, GOOD and BAD also trigger expectations for positive and negative outcomes.

2.2. Argument Graph

Understanding an editorial requires integrating explicit and implicit beliefs and belief justifications into an *argument graph* (Birnbaum, 1982; Flowers et al., 1982). Within this graph, beliefs are connected by links that indicate whether they support or attack one another. During text comprehension, every new belief or belief justification is integrated into the graph by using those links. The attack and support relationships are established from the application of the inference rules for: (a) recognizing beliefs and belief relationships, and (b) following belief justifications. For example, the following attack and support relationships are present in ED-JOBS:

Support Relationship between Beliefs: Friedman's general belief that the limitations on imports are bad[2] is supported by his specific belief that the limitations on imports will cost jobs in the U.S.

Supporting Cause-Effect Chain: Friedman's specific belief is supported by the cause-effect chain that indicates how a reduction in imports produces a reduction of jobs in export industries.

Attack Relationship between Beliefs: Friedman's specific belief attacks the Reagan administration's belief that the limitations will save jobs.

In general, support relationships are themselves supported by *warrants,* i.e., more basic beliefs which state that conclusions can be drawn from supporting evidences (Flowers et al., 1982; Toulmin, 1982). These warrants are recognized and instantiated by inference rules for recognizing beliefs and belief relationships. In addition, since warrants are just beliefs, they can themselves be attacked. For example, the support relationship between Friedman's general belief that the limitations are bad and his specific beliefs that the limitations on imports will cost jobs, is based on the following principle:

"IF a PLAN-P thwarts a PRESERVATION GOAL, THEN PLAN-P is BAD."

Beliefs of the form "X believes that C causes E" are usually supported by a belief whose contents represent an expansion of the cause-effect relationship. In this case, the warrant of the support relationship is provided by the following general rule:

"IF C causes E1 AND E1 causes E2 AND ... En causes E, THEN C causes E."

For example, Friedman's specific belief about the limitations on imports is supported by a cause-effect chain in ED-JOBS of how reductions in imports produce reductions in exports.

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[2] OpEd infers Friedman's belief from the affect description "disappointed".

2.3. Argument Units

Argument units (AUs) are abstract reasoning structures which organize: (a) belief, goals, and plans; and (b) support and attack chains of reasoning and relationships in arguments. Seven argument unit have been initially identified: AU-ACTUAL-CAUSE, AU-OPPOSITE-EFFECT, AU-EXPECTATION-FAILURE, AU-HYPOCRISY, AU-ACTUAL-EFFECT, AU-EQUIVALENCE, and AU-RELEVANT-ISSUE.

Each argument unit can be cued by specific constructs which involve: (a) *argument connectives* such as "on the contrary", "far from", "but", and "yet", which signal opposition and expectation failures; and (b) goal, plan, and belief relationships. As a result, following an argument involves recognizing these constructs, accessing the specific conceptualizations they refer to, mapping from them into their appropriate argument unit, and triggering that argument unit's inference rules for recognizing belief, support and attack chains of reasoning and relationships. This recognition process relies on expectations generated after an argument connective is found. These expectations involve specific information about abstract goal, plan, and belief relationships that precede and follow each corresponding argument connective.

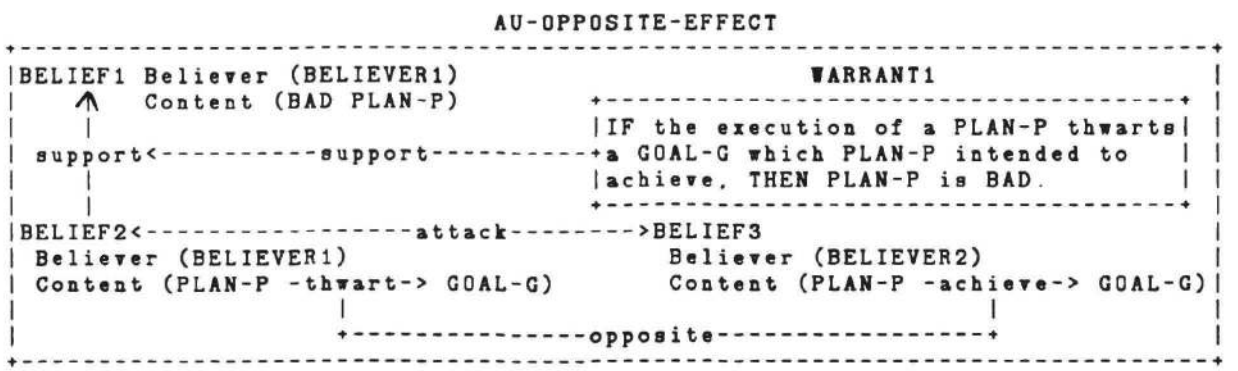
Instantiating argument units helps build argument graphs. For instance, consider AU-OPPOSITE-EFFECT. This argument unit embodies the following chain of reasoning:

> *Although Y believes that executing his PLAN P will achieve GOAL G, SELF does not believe this because SELF believes that executing P will thwart G. Therefore, SELF believes that P is bad.*

where SELF refers to the character who uses AU-OPPOSITE-EFFECT. This chain of reasoning contains a support relationship, a warrant of the support relationship, an attack relationship, and a declarative opposite relationship between two causal dependencies:

> *Support Relationship:* SELF's general belief that Y's PLAN P is bad is supported by SELF's specific belief that P thwarts GOAL G.
>
> *Warrant:* IF the execution of a PLAN P thwarts a GOAL G which P intended to achieve, THEN P is BAD.
>
> *Attack Relationship:* SELF's specific belief attacks Y's belief that Y's PLAN P achieves GOAL G.
>
> *Opposite Relationship:* Thwarting G by executing P is the opposite of achieving G by executing P.

These relationships are illustrated in the figure below.



Argument participants commonly convey AU-OPPOSITE-EFFECT using the following constructs:

1) *<Far from ACHIEVING GOAL-G, PLAN-P THWARTS GOAL-G>*
2) *<PLAN-P NOT-ACHIEVES GOAL-G. On the contrary, PLAN-P THWARTS GOAL-G.>*

where "far from" and "on the contrary" indicate the relation of opposition.

2.4. Building Editorial Memory

How does the comprehension process work and what does memory look like afterwards? Below follows a simplified trace of how OpEd processes ED-JOBS:

```
... measures ... disappointed us
    ===> PLAN execution --cause--> NEGATIVE-AFFECT
       ==infer==> B1: Friedman believes (measures are BAD)

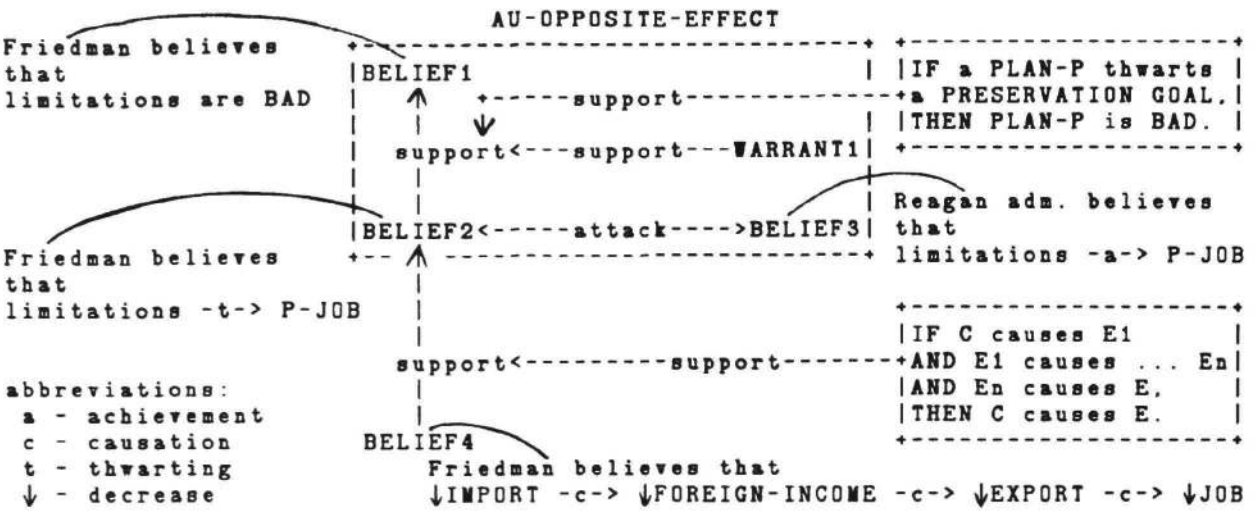
... limits ... bad for the nation
    ===> limits --cause--> GOAL FAILURE U.S.
       ==infer==> B2: Friedman believes (limits--cause--> GOAL FAILURE U.S.)
                  B2 supports B1
```

```
... Far from saving ... limitations cost ...
    ===> limits --achieve--> P-JOB     limits --thwart--> P-JOB
                    |                                  |
                    +----------opposite----------------+
       ==infer==> B2: Friedman believes (limits --thwart--> P-JOB U.S.)
        activate AU-OPPOSITE-EFFECT
        ==infer==> B3: Reagan adm. believes (limits --achieve--> P-JOB U.S.)

... import less ... earn fewer ... less to spend ... fewer jobs
    ===> CAUSE-EFFECT-CHAINO
         ↓import --cause-> ↓foreign-income --cause-> ↓export --cause-> ↓jobs

       ==infer==>  B4: Friedman believes (CAUSE-EFFECT-CHAINO)
                   B4 supports B3
```

The following diagram shows a simplified version of the memory representation currently constructed by OpEd while parsing ED-JOBS:



As the above diagram indicates, the bulk of the editorial memory is contained in the argument graph that depicts support/attack relationships between beliefs and cause-effect chains. Besides organizing several support/attack relationships, AU-OPPOSITE-EFFECT provide necessary inferences for: (a) recognizing and integrating into the argument graph the attack relationship; and (b) recognizing that the Reagan administration believes that the limitations will save jobs. In addition, AU-OPPOSITE-EFFECT captures the point of Friedman's argument and indexes the argument graph for subsequent retrieval.

3. Memory Retrieval

During question answering, the argument graph has to be accessed by search and retrieval processes. Thus, initial entry to the graph must be provided by structures that index beliefs and belief justifications. We have initially identified four indexing schemes based on how recall is done when answering questions about editorials: (1) indexing by containment (i.e., goal, plan, event, and state indexing); (2) indexing by affects; (3) indexing by argument participants; and (4) indexing by argument units.

(1) Indexing by Containment: Each instantiated goal, plan, event, and state indexes:

a) Beliefs and cause-effect chains which contain that goal, plan, event, or state. For example, the goal PRESERVE-JOB indexes both Friedman's specific belief and the Reagan administration's belief about the administration's PROTECTION-PLANs.

b) Structures used in representing that goal, plan, event, or state. For example, the goal PRESERVE-JOB indexes the Reagan Administration as the goal's holder.

(2) Indexing by Affects: Each instantiated affect indexes its associated belief. For example, Friedman's NEGATIVE-AFFECT indexes his belief that PROTECTION-PLANs are BAD.

(3) Indexing by Argument Participants: Each instantiated argument participant indexes:

a) The argument participant's *top beliefs*. A top belief is one that does not support other beliefs.

b) Argument units used by that participant. For example, OpEd accesses via Friedman the instantiation of AU-OPPOSITE-EFFECT.

(4) Indexing by Argument Units: Each instantiated argument unit indexes beliefs contained in its chains of reasoning and relationships. For example, AU-OPPOSITE-EFFECT indexes both Friedman's and the Reagan administration's beliefs about the administration's PROTECTION-PLANs.

Once an argument graph and indexing structures have been instantiated in episodic memory, OpEd demonstrates its comprehension by answering questions about the editorial. Selecting appropriate retrieval strategies depends upon parsing the question and analyzing the conceptual content into one of a number of conceptual question categories (Lehnert, 1978). Different question categories lead to different search and retrieval processes. These processes select indices according to the question's conceptual information. Once an index is selected, these processes will traverse access and memory links in order to locate an appropriate memory which will be retrieved.

Below we discuss a number of search and retrieval processes along with examples of their use during question answering about ED-JOBS. Answer generation in OpEd is by recursive descent through instantiated concepts, using patterns of generation associated with each uninstantiated knowledge structure. For example, the following is an actual answer currently generated by OpEd:

Q: Why have the limitations disappointed Friedman?

A: MILTON FRIEDMAN BELIEVES THAT VOLUNTARY EXPORT RESTRAINTS ON AUTOMOBILES FROM JAPAN NEGOTIATED BY THE REAGAN ADMINISTRATION WILL CAUSE THE LOSS OF JOBS IN THE U.S.

Notice the above answer is a detailed account of what OpEd knows about Friedman's belief. Thus, the answer includes information that humans generally omit, such as the fact that the limits were negotiated by Reagan. However, at this point we are not concerned with linguistic style in question answering. This is an area for future research.

3.1. Retrieval using Goal Indexing

Intended Plan Retrieval: Given an argument participant's goal, retrieve a belief which contains a plan of action to achieve that goal.

Q: How is the Reagan administration going to save jobs?

A: The Reagan administration believes that the limitations on imports will save jobs.

Argument Participant Retrieval: Given a goal, retrieve the argument participant who wants to achieve it.

Q: Who wants to save jobs?

A: The Reagan Administration.

3.2. Retrieval using Plan Indexing

Achieved and Thwarted Goal Retrieval: Given an argument participant's plan, retrieve beliefs which contain the effects of that plan's execution.

Q: What is the effect of the limitations on imports?

A: Friedman believes that the limitations on imports will cost jobs.
The Reagan administration believes that the limitations on imports will save jobs.

Argument Participant Retrieval: There are two cases:

1) Given a plan, retrieve the argument participant who is the actor of that plan.

   Q: Who will implement protectionist measures?

   A: The Reagan Administration.

2) Given a belief about a plan, retrieve the argument participant who holds that belief.

   Q: Who believes that the limitations on imports will save jobs?

   A: The Reagan administration.

Support Retrieval: Given a belief about a plan, retrieve the immediate support for that belief.

Q: Why does Friedman believe that the limitations on imports are bad?

A: Friedman believes that the limitations on imports will cost jobs in the U.S..

3.3. Retrieval using Event Indexing

Consequent State Retrieval: Given an event, retrieve a belief that contains a state or causal chain caused by that event.

Q: What will happen if the U.S. imports less?

A: Friedman believes that if the U.S. imports less, export profits of foreign countries will be reduced. Since this will reduce their total capital for importing, they will import less from the U.S. As a result, U.S. export industries will lose money and, therefore, they will lay off workers.

Plan Realization Retrieval: Given an event, retrieve a belief about a plan which realized that event.

Q: Why will the U.S. import less?

A: Friedman believes that the U.S. will import less because of the limitations on imports.

3.4. Retrieval using State Indexing

Causal Event Retrieval: Given a state, retrieve a belief that contains an event which causes that state.

Q: Why will export profits of foreign countries will be reduced?

A: Friedman believes that if the U.S. imports less, export profits of foreign countries will be reduced.

3.5. Retrieval using Affect Indexing

Affect Motivation Retrieval: Given an affect and an argument participant, retrieve its motivation:

Q: What has disappointed Friedman?

A: Voluntary export restraints on Japanese cars negotiated by the Reagan Administration.

Associated Belief Retrieval: Given an affect and its cause, retrieve the immediate support of its associated belief associated. If the support is not known, then retrieve the associated belief.

Q: Why have the limitations on imports disappointed Friedman?

A: Friedman believes that the limitations will cost jobs in the U.S..

3.6. Retrieval using Argument Participant Indexing

Top Belief Retrieval: Given an argument participant and a plan, retrieve the argument participant's top belief which contains that plan and its immediate support.

Q1: What does Friedman think about voluntary limits on Japanese cars?

A1: Friedman believes that the limitations on imports are bad because they will cost jobs.

Q2: What does the Reagan administration think about voluntary limits on Japanese cars?

A2: The Reagan administration believes that the limitations on imports will save jobs.

Argument Unit or Top Belief Retrieval: Given an argument participant, retrieve the argument units that contain his top beliefs. If he has not used any argument unit, retrieve his top beliefs.

Q: What is Friedman's argument?

A: That voluntary limits on Japanese cars are bad because they will cost jobs in the U.S.. Friedman believes that the Reagan Administration is wrong because the administration believes that voluntary limits on Japanese cars will save jobs in the U.S..

4. Comparison with other Work

In contrast to the *conceptual* process model presented here, Cohen (1983) has postulated a *structural* model for argument understanding. According to Cohen, understanding an argument requires building a tree where argument propositions are connected by a single evidence link. The root of the tree contains the major claim made in an argument. Relations between propositions are determined by using: (a) a *proposition analyzer* which produces a proposition from the input and integrates it into the tree built so far, (b) a *clue interpreter* which analyzes the role of special linguistic connectives (e.g., "as a result", "similarly", etc.), and (c) an *evidence oracle* which accesses a knowledge base and model of the speaker in order to determine whether an evidence relation exists between any two propositions.

Aside from the fact that Cohen's model was not implemented, it is theoretically limited since, in general, arguments do not comply with a coherent tree structure, but rather with a graph (Flowers et al. 1982). Furthermore, Cohen's *non-conceptual* tree structure does not show *how* explicit and implicit conceptualizations contained in a proposition relate to, and provide evidence for, conceptualizations contained in other propositions. Moreover, by using an *oracle*, the model avoids dealing with: (1) how lexical items are mapped from natural language into conceptual structures; (2) how world knowledge is represented and applied during the comprehension process; and (3) how abstract argument strategies are represented and applied. In contrast, OpEd understands complex editorial arguments by building a conceptual graph which captures interactions between goals, plans, events, states, beliefs, and argument

units. This conceptual graph results from recognizing and instantiating those knowledge structures along with causal, attack, and support relationships. In addition, this comprehension process also requires building indices which are subsequently used during question answering.

5. Future Work and Conclusions

We have presented memory organization and retrieval techniques for use by OpEd in understanding and answering questions about short politico-economic editorials. Currently, OpEd can read ED-JOBS and answer a number of questions about its conceptual content. Future questions that need to be addressed include:

* How is editorial memory organized after reading several editorials which present diverse opinions on a specific issue and how is memory retrieval performed in this case?
* How do different ideologies affect editorial comprehension, memory organization and retrieval?
* How are argument units used in order to generate arguments?

Five major points have been emphasized in this paper: (1) the internal conceptual representation of an editorial has several levels of complexity that include instantiations of conceptual structures which hold world knowledge and abstract knowledge about reasoning and argumentation; (2) a major portion of editorial memory is contained in an *argument graph;* (3) instantiating *argument units* helps build the *argument graph* by supplying inferences and argument strategy expectations; (4) search and retrieval processes use indexing structures to access *argument graphs;* (5) the points of an editorial are held by instantiated *argument units* containing top beliefs.

We believe that all arguments are composed of configurations of a fixed number of abstract *argument units.* Thus, we see the process of argument comprehension and generation fundamentally as one of accessing and instantiating these units. With OpEd we intend to explore and test this process model of reasoning and argument comprehension.

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