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ABSTRACT

This paper presents a theory of reasoning and argument comprehension currently implemented in *OpEd*, a computer system that reads short politico-economic editorials and answers questions about the editorial contents. We believe that all arguments are composed of a fixed number of abstract argument structures, which we call *Argument Units (AUs)*. Thus, argument comprehension is viewed in OpEd fundamentally as the process of recognizing, instantiating, and applying argument units. Here we discuss: (a) the knowledge and processes necessary to understand opinions, arguments, and issues which arise in politico-economic editorials; and (b) the relation of this research to previous work in natural language understanding. A description of OpEd and examples of its current input/output behavior are also presented in this paper.

I. INTRODUCTION

An intelligent computer program must be able to understand people's opinions and reasoning. This requires a theory of the processes and knowledge sources used during reasoning and argument comprehension. To develop such a theory, we have studied the problems that arise in understanding newspaper and magazine editorials which convey writers' opinions on politico-economic issues. This theory has been implemented in *OpEd* (Opinions to/from the Editor), a computer program that currently reads two short politico-editorial segments and answers questions about the editorial contents. Thus, OpEd also includes a theory of memory search and retrieval for reasoning and argument comprehension.

What are the computational issues currently addressed in OpEd? To illustrate the nature of the issues involved, consider the following editorial segment by Milton Friedman (1982):

ED-JOBS

Recent protectionist measures by the Reagan administration have ... disappointed ... us ... [Voluntary] limits on Japanese ... automobiles ... [and] ... [voluntary] limit[s] on steel ... by the Common Market ... are ... bad for the nation ... They do ... [not] ... promote the long-run health of the industries affected ... The ... problem of the auto[mobile] and steel industries is ... in both industries, average wage rates are twice as high as the average ... 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 spend on [American] exports ... The result will be fewer jobs in export industries.

Understanding ED-JOBS requires: (1) having a large amount of domain-specific knowledge, (2) recognizing beliefs and belief relationships, (3) following reasoning about plans and goals, (4) having abstract knowledge of argumentation, (5) mapping text into conceptual representation, and (6) indexing recognized concepts for later retrieval during question answering.

(1) **Domain-Specific Knowledge:** OpEd has a computational model of general politico-economic knowledge which helps it make sense of the discussion about import restrictions. OpEd knows about nations, consumers, workers, jobs, wage rates, imports, and exports. OpEd is also be able to handle references to politico-economic goals, plans, events, and states, such as: saving jobs, protectionist policies, importing goods, and drops in earnings/spending.

(2) **Recognizing Beliefs and Belief Relationships:** A basic problem in editorial comprehension is identifying the writer's explicit and implicit beliefs and how they support one another. For example, after reading the first sentence of ED-JOBS, OpEd infers that Friedman is against the Reagan administration's protectionist policies, although this opinion is not explicitly stated. OpEd is also able to recognize other individuals' beliefs and how they are supported or attacked by the writer's beliefs. For instance, OpEd understands that in the sentence "[These import restrictions] do not promote the long-run health of the industries affected," Friedman attacks the implicit belief of the Reagan administration that the limitations will help the American automobile and steel industries.

(3) **Reasoning about Plans and Goals:** OpEd identifies and keeps track of chains of reasoning which support beliefs about goals and plans. This requires: (1) recognizing explicit and implicit cause-effect relationships and (2) applying OpEd's politico-economic knowledge to aid the recognition process. For example, when processing ED-JOBS, OpEd realizes that Friedman's belief that import restrictions will cost jobs is supported by a cause-effect chain on how reductions in imports to the U.S. cause reductions in exports by the U.S. and, consequently, reductions in jobs in U.S. export industries.

(4) **Abstract Knowledge of Argumentation:** OpEd has abstract knowledge of argument structure which is independent of domain-specific knowledge, i.e., knowledge fundamental to understanding and generating arguments in any domain. This abstract knowledge of argumentation is organized by memory structures called *Argument Units (AUs)* (Alvarado et al., 1985a, 1985b). For example, in ED-JOBS, Friedman uses the following argument unit:

AU-OPPOSITE-EFFECT

Although OPPONENT believes that his PLAN P achieves GOAL G, SELF does not believe that P achieves G because SELF believes that P thwarts G. Therefore, SELF believes that P is BAD.

Thus, Friedman argues that he is against limitations on imports because they will not save but cost jobs. During editorial comprehension, OpEd recognizes and applies this argument unit to understand Friedman's attack on the Reagan administration's policies.

(5) **Mapping Text into Conceptual Representations:** OpEd keeps track of the conceptual contents of the editorial by building and maintaining an internal conceptual model of all recognized beliefs, belief relationships, reasoning chains, and argument units. This conceptual model, known as an *argument graph* (Flowers et al., 1982), represents explicitly beliefs supports and attacks as well as relationships among politico-economic plans, goals, events, and states. To build the argument graph, OpEd parses words or phrases into conceptual structures and integrates these structures into the graph. This is not a trivial process, since mapping editorial text into conceptual representations involves handling numerous tasks including: (a) disambiguating words; (b) resolving pronoun references; (c) recognizing, instantiating and applying conceptual structures; and (d) inferring implicit information by applying appropriate knowledge sources. For example, OpEd understands that in the phrase "the health of the [American automobile and steel] industries," the word "health" does not refer to the physical state of the industries but rather to their economic well-being.

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(6) **Question Answering:** During question answering, OpEd accesses, retrieves, and generates into English beliefs, belief relationships, and argument units. OpEd has search and retrieval processes capable of gaining initial access to the argument graph. Initial entry is provided by indexing structures created during editorial comprehension. These structures index instances of domain-specific objects, plans, goals, events, states, causal relationships, reasoning chains, beliefs, belief relationships, and argument units. The theory of question comprehension, indexing, and retrieval implemented in OpEd was originally developed by Lehnert (1978) and extended in (Dyer and Lehnert, 1982) and (Alvarado et al., 1985a). Consider the following question posed to OpEd after reading ED-JOBS:

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

A: MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION WILL THWART THE PRESERVATION OF JOBS FOR U.S..

MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION DO NOT LEAD TO THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY.

THE REAGAN ADMINISTRATION BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION LEAD TO THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY.

THE REAGAN ADMINISTRATION BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION ACHIEVE THE PRESERVATION OF JOBS FOR U.S..

To answer this question OpEd uses: (a) indexing structures from ECONOMIC-PROTECTION-PLANS to their instantiations and access links between these instances and their associated BELIEFS; and (b) retrieval functions that take PLANS as input and retrieve appropriate BELIEFS about the PLANS' effects.

Editorial understanding is a natural next step and logical challenge for research in natural language understanding. Current narrative understanding programs are capable of reading stories involving stereotypic situations, goal and planning situations, and complex human interactions (Cullingford, 1981; DeJong, 1982; Dyer, 1983; Lebowitz, 1983; Wilensky, 1983). However, those programs lack the ability to understand editorial text since this requires knowledge of argumentation and reasoning in addition to the sources of knowledge used for comprehension of narratives. In contrast, OpEd builds upon knowledge constructs and processing strategies resulting from previous work in narratives. OpEd's process model involves combining the following:

1) Knowledge representation constructs used in conceptual analysis of narratives, including events (Schank, 1975; Schank and Carbonell, 1979); goals and plans (Schank and Abelson, 1977; Carbonell, 1981; Wilensky, 1983); reasoning scripts (Dyer, Cullingford, and Alvarado, in press; Flowers and Dyer, 1984); and MOPs (Schank, 1982).
2) Techniques for modeling argument dialogues;
3) A taxonomy of beliefs and Argument Units;
4) Techniques for integrated in-depth parsing of narratives;
5) Search and retrieval techniques to model the process of question answering.

Here, we focus on the first four**. Their use in editorial comprehension will be illustrated by means of examples using excerpts from ED-JOBS and ED-RESTRICTIONS, another segment handled by OpEd and taken from an editorial by Lance Morrow (1983):

ED-RESTRICTIONS

... The American machine-tool industry ... [is] seeking protection from foreign competition. The industry has been ... hurt by ... cheaper ... machine tools from Japan ... [T]he toolmakers argue [that] ... restrictions ... [on imports] ... must be imposed so that the ... industry can survive ... It is a ... wrongheaded argument ... [R]estrictions on [imports] ... would mean that ... [American] manufacturers ... would have to make do with more expensive ... American machine tools. Inevitably those American manufacturers would produce more expensive ... products ... They would lose sales ... Then those manufacturers would ... demand protection against ... foreign competition.

** OpEd's question answering model is described in (Alvarado et al., 1985a).

II. REASONING COMPREHENSION

Editorial arguments involve complex reasoning chains which justify beliefs about plans and goals. These chains show: (1) why plans should/shouldn't be selected, implemented or terminated; or (2) why goals should/shouldn't be pursued. Thus, knowledge of goals and plans is essential to follow and keep track of reasoning chains. For instance, OpEd realizes the following goal and planning situations in order to comprehend ED-RESTRICTIONS: (a) American machine-tool manufacturers have an active PRESERVE-FINANCES goal since their finances are being threatened by Japanese imports; and (b) to protect their finances, American machine-tool manufacturers are PETITIONing that the American government implement ECONOMIC-PROTECTION-PLANS against the market COMPETITION by the Japanese machine-tool industry.

In OpEd, *reasoning scripts* (Flowers and Dyer, 1984) are used to organize prespecified reasoning chains involving cause-effect relationships among politico-economic goals, plans, events, and states (Dyer, Cullingford, and Alvarado, in press). OpEd recognizes and instantiates these reasoning scripts when following belief justifications which contain structural gaps, i.e., justifications involving causal chains with implicit cause-effect relationships. Consider how OpEd processes the following fragment of ED-JOBS:

Recent protectionist measures by the Reagan administration have disappointed us ... 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 spend on American exports. The result will be fewer jobs in export industries.

Q: Why does Milton Friedman believe that the limitations on imports will cost jobs?

A: MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION WILL THWART THE PRESERVATION OF JOBS FOR U.S. BECAUSE MILTON FRIEDMAN BELIEVES THAT AS A CONSEQUENCE OF PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION, U.S. IMPORTS FEWER PRODUCTS; IF U.S. IMPORTS FEWER PRODUCTS, THEN THERE IS A DECREASE IN PROFITS OF FOREIGN COUNTRIES; IF THERE IS A DECREASE IN PROFITS OF FOREIGN COUNTRIES, THEN FOREIGN COUNTRIES BUY FEWER AMERICAN EXPORTS; IF FOREIGN COUNTRIES BUY FEWER AMERICAN EXPORTS, THEN THERE IS A DECREASE IN PROFITS OF EXPORT INDUSTRIES; IF THERE IS A DECREASE IN PROFITS OF EXPORT INDUSTRIES, THEN THERE IS A DECREASE IN JOBS IN EXPORT INDUSTRIES; A DECREASE IN JOBS IN EXPORT INDUSTRIES THWARTS THE PRESERVATION OF JOBS FOR U.S..

In order to understand Friedman's complex reasoning chain, which justifies his belief that the limitations will cost jobs, OpEd applies the following reasoning script:

SR-DROP-FOREIGN-SPENDING-->DROP-JOBS

IF COUNTRY C1 spends less on PRODUCT P produced by PRODUCER P1 from COUNTRY C2, THEN there is a decrease on the EARNINGS of PRODUCER P1. AND IF there is a decrease on the EARNINGS of PRODUCER P1, THEN there is a decrease in the number of OCCUPATIONS in PRODUCER P1.

During instantiation, C1 is bound to "foreign countries," C2 to "U.S.," and P1 to "U.S. export industries." As a result, OpEd infers that a decrease in U.S. exports causes a decrease in jobs in U.S. export industries. Thus, the use of reasoning scripts allows OpEd to infer missing steps in incomplete chains of reasoning in editorial text.

III. BUILDING ARGUMENT GRAPHS

Flowers et al. (1982) have presented a theory of the reasoning processes used when engaging in adversary arguments, i.e., arguments in which the participants do not expect to convince one another or to be convinced. Flowers et al. represent an adversary argument in terms of an *argument graph*, which contains all propositions used by the argument participants. Propositions are connected by links that indicate how they support or attack one another. The argument graph aids understanding because the role of every new proposition is determined by establishing how the proposition can be integrated into the graph by using attack or support links.

In OpEd, argument graphs are used to keep track of all beliefs and belief supports/attacks implicitly or explicitly mentioned in editorial arguments. For example, OpEd recognizes and integrates into an argument graph the following attack and support relationships present in ED-RESTRICTIONS:

Support Relationship between Beliefs: Morrow's general belief that import restrictions on Japanese machine tools are bad is supported by his specific belief that restrictions will cause a drop in earnings of American manufacturers.

Supporting Cause-Effect Chain: Morrows's specific belief is supported by the cause-effect chain on how a reduction in imports causes a reduction in earnings of American manufacturers.

Attack Relationship between Beliefs: Morrow's specific belief attacks the American machine-tool industry's belief that the limitations will help it recover from losses caused by foreign competition.

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 et al., 1979). Since warrants are also beliefs, they can themselves be attacked. For example, the support relationship between Morrow's general belief that import restrictions are bad and his specific beliefs that import restrictions cause drops in earnings is based on the following principle:

IF a PLAN P thwarts a GOAL G2 as important as the GOAL G1 which intended PLAN P, THEN PLAN P is BAD.

In this warrant, BAD is an evaluative place holder (much like the act DO in CD Theory (Schank, 1975)) for negative outcomes, such as goal violations and expectations failures.(For more details on BAD see Alvarado et al., 1985a.) In Morrow's editorial, the goal being thwarted is PRESERVE-FINANCES of American manufacturers. Thus, Morrow can argue against the restrictions on Japanese exports of machine tools because he shows that they will cause a violation of a preservation goal. Similarly, the support relationship between Morrow's specific belief and his cause-effect chain on how a reduction in imports produces a reduction in earnings of American manufacturers is based on the warrant:

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

Thus, Morrow can support his specific belief if he can coherently expand it into a cause-effect chain.

OpEd uses warrants to generate expectations about possible belief justifications. For example, after reading the sentence "[The belief of the American machine-tool industry] is wrongheaded," OpEd not only recognizes that Morrow is against import restrictions, but also expects to hear one of the following justifications:

* Restrictions do not achieve the goal that intended them, namely PRESERVE-FINANCES;

* Restrictions thwart their intending goal;

* Restrictions thwart other goals more important than or equivalent to their intending goal.

In ED-RESTRICTIONS, the third expectation is fulfilled and OpEd integrates this justification into the argument graph. OpEd retrieves this justification when answering the following question:

Q: Why does Lance Morrow believe that restrictions on imports are bad?

A: LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT IS BAD BECAUSE LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT MOTIVATES THE PRESERVATION OF NORMAL PROFITS OF AMERICAN INDUSTRIES.

LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT IS BAD BECAUSE LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT MOTIVATES THE PRESERVATION OF NORMAL PROFITS OF AMERICAN INDUSTRIES; AND THE PRESERVATION OF NORMAL PROFITS OF AMERICAN INDUSTRIES INTENDS PERSUASION PLAN BY AMERICAN INDUSTRIES ABOUT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT.

VI. BELIEFS AND ARGUMENT UNITS

Beliefs can be directly recognized if they are explicitly mentioned using phrases such as "X believe SITUATION." For example, the following sentence "The current administration believes that unilateral disarmament is bad for the U.S.," explicitly indicates the current administration's belief with respect to unilateral disarmament. However, editorial writers seldom state their beliefs explicitly. As a result, their beliefs must be inferred from other explicit standpoints, from affective reactions, and from various argument units.

A. Recognizing Beliefs from Standpoints and Affective Reactions

Beliefs can be inferred from explicitly stated support and opposition standpoints. For instance, in the following excerpt from (Friedman, 1982) "Those of us who have opposed export quotas on grain, ... have defended [the] administration opposition to the pipeline deal," we infer that Friedman believes that the export quotas are bad and that both Friedman and the administration believe that the pipeline deal is a bad idea. These inferences rely on the application of the following rules:

** IF X opposes SITUATION S, THEN infer that X believes that S is BAD.*

** IF X supports Y's attack of SITUATION S, THEN infer that X believes that S is BAD.*

where SITUATION S corresponds to a goal/planning situation. These inference rules are part of a larger set of belief inference rules described in (Alvarado, et al., 1985b).

Beliefs can also be signaled by explicit emotional reactions (Dyer, 1983) often stated in arguments. The belief inference rules organized by affective reactions are as follows:

** IF a SITUATION S produces a negative affective reaction for X (due to X experiencing a goal or expectation failure), THEN infer that X believes that S is BAD.*

** IF a SITUATION S produces a positive affective reaction for X (due to X experiencing a goal or expectation achievement), THEN infer that X believes that S is GOOD.*

where, as in the case of BAD, GOOD is an evaluative place holder for positive outcomes. For example, in the first sentence of ED-JOBS, Friedman's disappointment indicates to OpEd his belief that the Reagan administration's protectionist policies are BAD, i.e., they cause (or will cause) goal violations or expectations failures. These violations are confirmed later when OpEd reads that the limitations (1) will not help the auto and steel industries and (2) will cost jobs. OpEd retrieves the reason for Friedman's disappointment when answering the following question:

Q: Why have the limitations on imports disappointed Milton Friedman?

A: MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION WILL THWART THE PRESERVATION OF JOBS FOR U.S.

MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION DO NOT LEAD TO THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY.

B. Argument Unit Taxonomy

Argument units (Alvarado et al., 1985a, 1985b) are abstract argument structures which package patterns of belief support/attack relationships and chains of reasoning. When combined with domain-specific knowledge, these abstract argument structures can be used to argue about issues involving plans, goals, and beliefs in the particular domain. Thus, argument comprehension is viewed in OpEd fundamentally as the process of recognizing, instantiating, and applying argument units.

The abstract relationships embodied by AUs fall within one of following categories:

1) Support/attack relationships on why plans should or shouldn't be selected, implemented or terminated;

2) Support/attack relationships on why goals should or shouldn't be pursued; or

3) Support/attack relationships on why beliefs do or don't hold within ideological contexts.

Here, we focus on the first category. In particular, we describe four AUs used in ED-JOBS and ED-RESTRICTIONS, namely: AU-ACTUAL-CAUSE, AU-OPPOSITE-EFFECT, AU-EQUIVALENCE, and AU-SPIRAL-EFFECT.

1. AU-ACTUAL-CAUSE

AU-ACTUAL-CAUSE embodies the following reasoning chain:

Although OPPONENT believes that his PLAN P achieves GOAL G, SELF does not believe that P achieves G because SELF believes that: (1) it is SITUATION S which thwarts G, and (2) P does not affect S. Therefore, SELF believes that executing P is BAD planning.

This argument unit is depicted in figure 1. Friedman uses AU-ACTUAL-CAUSE in ED-JOBS to argue that restrictions on imports do not help the American automobile and steel industries because their economic problems are caused by high wage rates. Here, P refers to ECONOMIC-PROTECTION-PLANS, G to PRESERVE-FINANCES of the auto and steel industries, and S to EARNINGS of workers in these industries. In this case, recognition of AU-ACTUAL-CAUSE is top-down since:

a) OpEd has inferred from Friedman's disappointment his belief that ECONOMIC-PROTECTION-PLANS are BAD.

b) OpEd knows that a plan is BAD if it does not achieve its intending goal. This expectation is confirmed when OpEd reads that ECONOMIC-PROTECTION-PLANS "do not promote the long-run health of the [automobile and steel] industries." At this point OpEd expects to hear why the ECONOMIC-PROTECTION-PLANS do not help these industries.

c) OpEd's expectation is fulfilled as it reads that the economic problem of these industries is caused by high wage rates which, as OpEd knows, are not affected by import restrictions.

This instantiation of AU-ACTUAL-CAUSE is retrieved when OpEd answers the following question:

Q: What does Milton Friedman believe?

A: MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION ARE BAD BECAUSE MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION DO NOT LEAD TO THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY. MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION DO NOT LEAD TO THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY BECAUSE MILTON FRIEDMAN BELIEVES THAT NORMAL SALARY IN THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY HIGHER THAN THE NORM THWARTS THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY. MILTON FRIEDMAN BELIEVES THAT THE REAGAN ADMINISTRATION IS WRONG BECAUSE THE REAGAN ADMINISTRATION BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION LEAD TO THE ACHIEVEMENT OF NORMAL PROFITS OF THE STEEL INDUSTRY AND THE AUTOMOBILE INDUSTRY.

2. AU-OPPOSITE-EFFECT

AU-OPPOSITE-EFFECT embodies the following reasoning chain:

Although OPPONENT believes that his PLAN P achieves GOAL G, SELF does not believe that P achieves G because SELF believes that P thwarts G. Therefore, SELF believes that P is BAD.

This argument unit is shown in figure 2. In ED-JOBS, Friedman uses AU-OPPOSITE-EFFECT to argue that the limitations will cost jobs in the U.S.. In this case, P refers to ECONOMIC-PROTECTION-PLANS by the Reagan administration and G to PRESERVE-JOBS. In ED-JOBS, recognition of AU-OPPOSITE-EFFECT is bottom-up since OpEd infers it from the OPPOSITE RELATION between expected results of import restrictions, namely, saving jobs and costing jobs. Notice that AU-OPPOSITE-EFFECT allows OpEd to infer that: (a) the Reagan administration believes that import restrictions will save jobs; and (b) this belief is attacked by Friedman. This instantiation of AU-OPPOSITE-EFFECT is also retrieved when OpEd answers the question:

Q: What does Milton Friedman believe?

A: MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION ARE BAD BECAUSE MILTON FRIEDMAN BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION WILL THWART THE PRESERVATION OF JOBS FOR U.S.. MILTON

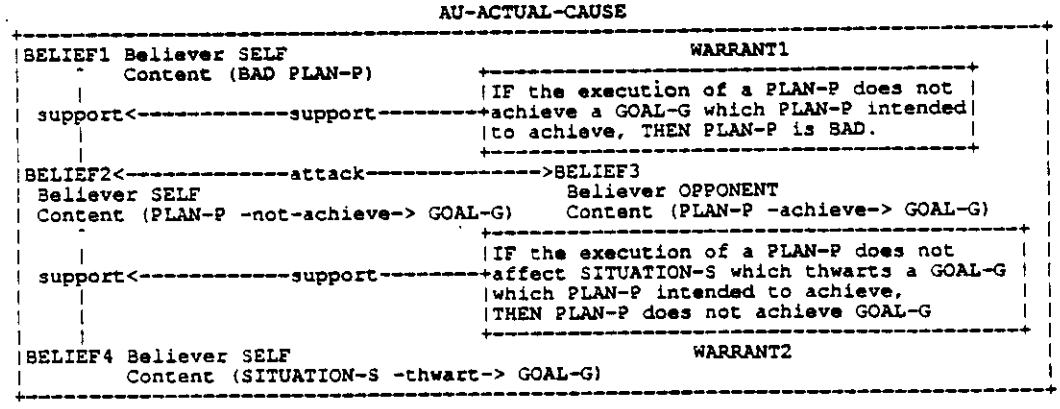

Figure 1. AU-ACTUAL-CAUSE

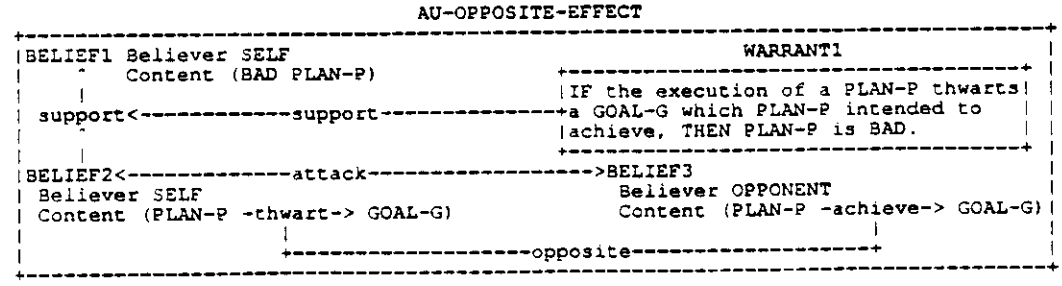

Figure 2. AU-OPPOSITE-EFFECT

FRIEDMAN BELIEVES THAT THE REAGAN ADMINISTRATION IS WRONG BECAUSE THE REAGAN ADMINISTRATION BELIEVES THAT PROTECTIONIST POLICIES BY THE REAGAN ADMINISTRATION ACHIEVE THE PRESERVATION OF JOBS FOR U.S..

3. AU-EQUIVALENCE

AU-EQUIVALENCE embodies the following reasoning chain:

Although OPPONENT believes that his PLAN P achieves GOAL G1, SELF believes that P thwarts GOAL G2 which is as important as G1. Therefore, SELF believes that P is BAD.

AU-EQUIVALENCE is shown in figure 3. Notice that AU-OPPOSITE-EFFECT is a specialization of AU-EQUIVALENCE where GOAL G1 and GOAL G2 correspond to the same GOAL G. However, AU-OPPOSITE-EFFECT is triggered by an opposite relationship rather than by an equivalence one, as in the case of AU-EQUIVALENCE. Morrow uses AU-EQUIVALENCE in ED-RESTRICTIONS to argue that restrictions on imports will cause losses to American manufacturers. In ED-RESTRICTIONS, P refers to ECONOMIC-PROTECTION-PLAN by the U.S. government, G1 to PRESERVE-FINANCES of American machine-tool industry, and G2 to PRESERVE-FINANCES of other American manufacturers. In this case, recognition of AU-EQUIVALENCE is top-down since:

a) OpEd knows that Morrow is against import restrictions after reading "[The belief of the American machine-tool industry] is wrongheaded." At this point, however, OpEd does not know why Morrow is against protectionist policies. Yet, OpEd expects to hear that these policies (1) will have negative consequences (e.g., goal or expectation violations) or (2) will not achieve their intending goal.

b) While following Morrow's cause-effect chain, OpEd realizes that costing sales to other American manufacturers will thwart a PRESERVE-FINANCES goal for them. Thus, OpEd realizes that this goal is equivalent to the goal that intended the ECONOMIC-PROTECTION-PLAN in the first place (i.e., PRESERVE-FINANCES of American machine-tool industry).

This instantiation of AU-EQUIVALENCE is retrieved when OpEd answers the following question:

Q: What does the Lance Morrow believe?

A: LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT IS BAD BECAUSE LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT MOTIVATES THE PRESERVATION OF NORMAL PROFITS OF AMERICAN INDUSTRIES. LANCE MORROW BELIEVES THAT THE AMERICAN MACHINE TOOL INDUSTRY IS WRONG BECAUSE THE AMERICAN MACHINE TOOL INDUSTRY BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT ACHIEVES THE PRESERVATION OF NORMAL PROFITS OF THE AMERICAN MACHINE TOOL INDUSTRY.

4. AU-SPIRAL-EFFECT

AU-SPIRAL-EFFECT embodies the following reasoning chain:

Although OPPONENT believes that his PLAN P achieves GOAL G1, SELF believes that P thwarts a GOAL G2 which is as important as G1. In addition, SELF believes that G2 will intend P', another instance of P. Therefore, SELF believes that P is BAD.

AU-SPIRAL-EFFECT is depicted in figure 4. Morrow uses AU-SPIRAL-EFFECT in ED-RESTRICTIONS to argue that restrictions on Japanese machine-tool imports will generate more petitions for import restrictions. In ED-RESTRICTIONS, P refers to ECONOMIC-PROTECTION-PLAN by the American government, G1 to PRESERVE-FINANCES of American machine-tool manufacturers, G2 to PRESERVE-FINANCES of other American manufacturers, and P' to the PERSUASION-PLAN of these manufacturers to get ECONOMIC-PROTECTION-PLANS implemented. In ED-RESTRICTIONS, recognition of AU-SPIRAL-EFFECT is top-down since (1) AU-EQUIVALENCE is active and (2) AU-SPIRAL-EFFECT can follow other AUs that embody arguments about plans' consequences. From the instantiation of AU-EQUIVALENCE, OpEd already knows about the expected goal violation resulting from restricting Japanese exports of machine tools to the U.S.. OpEd knows that if this goal violation intends another instance of (or a PETITION for) the ECONOMIC-PROTECTION-PLAN, then AU-SPIRAL-EFFECT is being used. Consequently, the sentence "Then those manufacturers would demand protection against foreign competition," causes OpEd to activate AU-SPIRAL-EFFECT. This instantiation of AU-SPIRAL-EFFECT is also retrieved when OpEd answers the question:

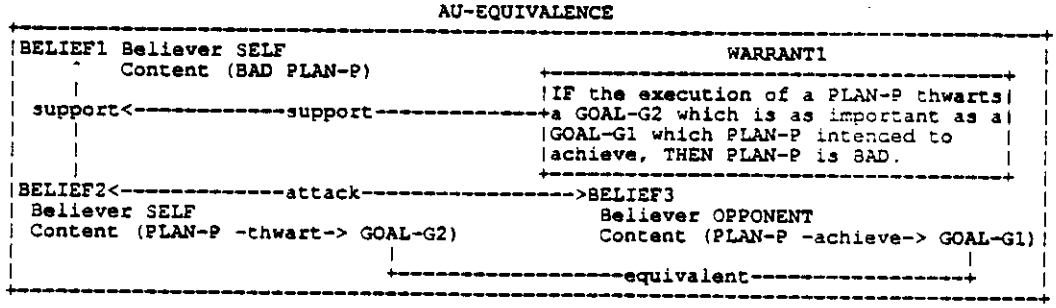

Figure 3. AU-EQUIVALENCE

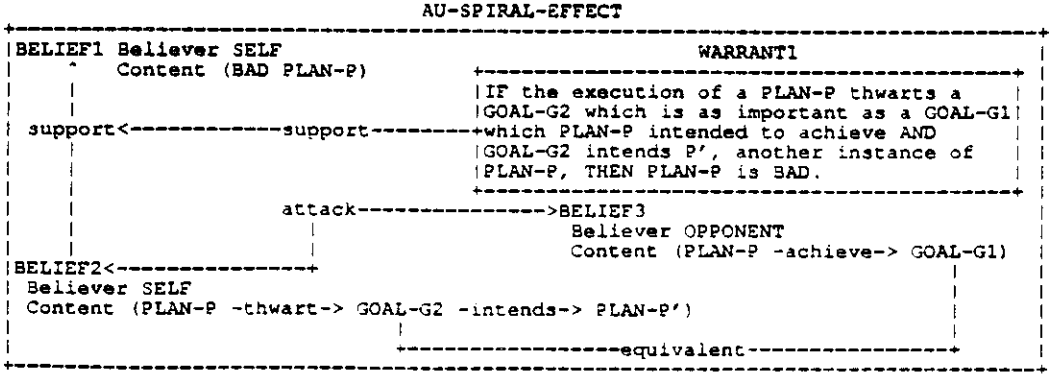

Figure 4. AU-SPIRAL-EFFECT

Q: What does Lance Morrow believe?

A: LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT IS BAD BECAUSE LANCE MORROW BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT MOTIVATES THE PRESERVATION OF NORMAL PROFITS OF AMERICAN INDUSTRIES: AND THE PRESERVATION OF NORMAL PROFITS OF AMERICAN INDUSTRIES INTENDS PERSUASION PLAN BY AMERICAN INDUSTRIES ABOUT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT. LANCE MORROW BELIEVES THAT THE AMERICAN MACHINE TOOL INDUSTRY IS WRONG BECAUSE THE AMERICAN MACHINE TOOL INDUSTRY BELIEVES THAT PROTECTIONIST POLICY BY THE AMERICAN GOVERNMENT ACHIEVES THE PRESERVATION OF NORMAL PROFITS OF THE AMERICAN MACHINE TOOL INDUSTRY.

V. THE OpEd SYSTEM

OpEd has been designed as an in-depth understander of editorial text. OpEd can read short politico-economic editorial segments and demonstrate its comprehension by answering questions about the editorial contents. In OpEd, editorial comprehension and question answering are handled by the same conceptual parser; thus, OpEd is an integrated process model of comprehension, search, and retrieval. Input editorial segments are in English and contain the essential wording, issues, and arguments of the original editorials. During editorial comprehension, OpEd builds the argument graph which represents the conceptual contents of the editorial. When answering questions, it is the argument graph which is queried, since OpEd cannot remember the wording used in the editorial segment. Input questions are in English and the answers retrieved are converted from memory representation to English by an English generator.

A. OpEd's Architecture

OpEd consists of seven major interrelated components, as shown in figure 5.

(1) **Semantic Memory:** OpEd's semantic memory embodies: (1) a computational model of politico-economic knowledge; and (2) OpEd's abstract knowledge of argumentation. Each knowledge structure has attached processes called *demons* which perform knowledge application and knowledge interaction tasks, such as inferring belief and belief relationships, following reasoning about plans and goals, and inferring argument units. Each class of knowledge structure (i.e., goals, plans, beliefs, AUs, etc.) also has an associated generation pattern which is accessed by OpEd's English generator (7).

(2) **Lexicon:** OpEd has a lexicon where words, phrases, roots, and suffixes are declared in terms of knowledge structures in semantic memory (1). Each lexical item also has attached demons which perform such functions as role binding, word disambiguation, and resolving pronoun references.

(3) **Demon-Based Parser:** Input editorial text is parsed by an integrated demon-based parser based on the conceptual parser implemented in BORIS (Dyer, 1983), an in-depth understander of narratives. Each input sentence is read form left to right, on a word-by-word or phrase basis. When a lexical item is recognized, a copy of its associated conceptualization is placed into OpEd's short-term memory or working memory (4). Copies of the lexical item's demons and its conceptualization's demons are placed into a demon agenda that contains all active demons. Then, the parser tests all active demons and executes those whose test conditions are satisfied. After demons are executed, they are removed from the agenda.

(4) **Working Memory:** When demons are executed, they bind together conceptualizations in working memory and, as a result, build the conceptual representation of the input sentence. Thus, working memory maintains the current context of the sentence being parsed.

(5) **Argument Graph:** Also resulting from demon execution, the conceptualizations created in working memory (4) get interactively integrated with instantiated knowledge structures indexed by semantic memory's uninstantiated structures (1). These instantiations compose the editorial's argument graph which both maintains the current context and represents the portion of the editorial read so far. Thus, the argument graph can be viewed as OpEd's episodic memory (Tulving, 1972), as opposed to OpEd's semantic memory (1) which contains what OpEd knows before reading the editorial.

(6) **Memory Search and Retrieval Processes:** During question answering, the argument graph (5) also maintains the current context from which questions are understood. Input questions are parsed by the same demon-based parser (3) used for editorial comprehension, which, as before, builds the conceptual representations of the questions in the working memory (4). Question-answering demons attached to WH-words are activated whenever such words are encountered at the beginning of input questions. Aside from determining conceptual question categories (Lehnert, 1978), these demons activate appropriate search and retrieval demons which access the argument graph and return conceptual answers.

(7) **English Generator:** Once an answer is found, it is generated in English by OpEd's recursive-descent English generator. This generator produces English sentences in a left-to-right manner by traversing instantiated knowledge structures and using generation patterns associated with uninstantiated knowledge structures. For example, instantiations of AU-OPPOSITE-EFFECT are generated using the pattern:

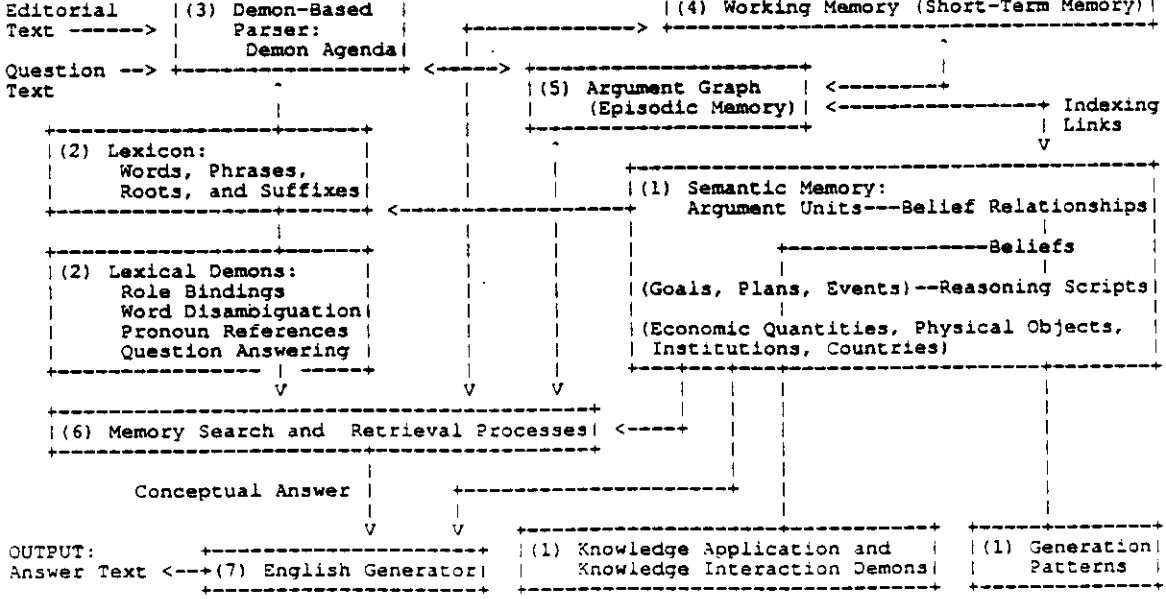

Figure 5. Diagram of OpEd's Components

<BELIEF1> "because" <BELIEF2> "." <SELF> "believe that" <OPPONENT> "be wrong because" <BELIEF3> "."

where: (1) SELF, OPPONENT, BELIEF1, BELIEF2, and BELIEF3 are components of AU-OPPOSITE-EFFECT, as indicated in figure 2; and (2) the verbs "to believe" and "to be" are conjugated according to contents of SELF, OPPONENT, and BELIEF3.

B. Current Status

OpEd is written in T (Rees, et al., 1984), a lexically-scoped Scheme-based dialect of Lisp running on Apollo Domain workstations. OpEd uses the knowledge representation system provided by GATE (Mueller and Zernik, 1984), an integrated set of graphical Artificial Intelligence development tools.

Currently, OpEd can handle two short editorial segments, (i.e., ED-JOBS and ED-RESTRICTIONS) and various conceptual question categories. The first version of OpEd (Alvarado et al., 1985a) contained enough knowledge to handle a fragment of ED-JOBS. Later, the scope of OpEd was extended to read completely ED-JOBS and ED-RESTRICTIONS. This expansion did not require modifying OpEd's process model of reasoning and argument comprehension, but rather: (a) augmenting OpEd's lexicon, politico-economic knowledge, and argument units; and (b) specifying the demons attached to the lexical items and conceptual constructs added. In addition, OpEd's search and retrieval processes did not require any modifications to handle questions about ED-RESTRICTIONS. This follows from the fact that these processes do not depend on "key" lexical items or specific instantiations of conceptual constructs, but rather on general classes of conceptual constructs, such as goals, plans, beliefs, and AUs. Thus, OpEd's process model is not tailored to any specific editorial and can be viewed as a prototype of computer comprehension of editorial text. Our current goal in the OpEd project is to advance our fundamental understanding of the processes and knowledge structures involved in argument text comprehension, rather than to produce a robust editorial comprehension system.

VI. FUTURE WORK

We believe that the theory implemented in OpEd constitutes the foundation for an integral theory of argument comprehension and argument generation. Such a theory should ultimately help explain not only how people's opinions are understood, but also:

Reasoning Intentionality: Whether the reasoning is intended to explain or to convince.

Reasoning Errors: Whether the reasoning is sound.

Agreement: The computational meaning of agreement and its relation to ideologies.

Efficacy of Reasoning and Argument Units: The computational meaning of persuasion and the use of argument units in persuasive arguments.

Long-term Memory Organization and Retrieval: How memory is organized and how retrieval is affected after similar editorials have been read and integrated into memory.

Learning Argument Units: How argument units and reasoning chains are learned.

Argument Generation: How argument units are used to generate arguments.

VII. CONCLUSIONS

We have presented a theory of reasoning and argument comprehension implemented in OpEd to understand short editorial segments. Four major points have been emphasized in this paper:

* Understanding arguments requires: (1) recognizing beliefs, belief support/attack relationships, and *argument units;* (2) following belief justifications; and (3) building *argument graphs.*

* Beliefs can be inferred from explicit standpoints, emotional reactions, and argument units.

* To follow belief justifications, it is necessary to: (1) trace the evolution of goal/plan situations; and (2) apply *reasoning scripts* to infer implicit cause-effect relationships.

* Instantiating argument units helps recognize and integrate into the argument graph implicit beliefs and belief support/attack relationships.

We believe that all arguments are composed of coherent configurations of argument units. Thus, argument comprehension is the process of recognizing, instantiating, and applying these units. We have designed OpEd to explore this process model in the domain of editorial text.

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