

Communicative Acts for Generating Natural Language Arguments

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Abstract

The ability to argue to support a conclusion or to encourage some course of action is fundamental to communication. Guided by examination of naturally occurring arguments, this paper classifies the communicative structure and function of several different kinds of arguments and indicates how these can be formalized as plan-based models of communication. The paper describes the use of these communication plans in the context of a prototype which cooperatively interacts with a user to allocate scarce resources. This plan-based approach to argument helps improve the cohesion and coherence of the resulting communication.

Introduction

Knowledge-based systems are often called upon to support their results or conclusions or to justify courses of action which they recommend. These systems, therefore, are often placed in the position of attempting to influence the beliefs and/or behavior of their users and yet they often do not have sophisticated capabilities for doing so. The first step in arguing for some proposition or some course of action is ensure that it is understood by the addressee. A number of techniques have been developed to automatically generate natural language descriptions or expositions, for example, to describe what is meant by some abstract concept (McKeown 1985) or to explain a complex mechanism in a manner tailored to an individual user (Paris 1987). However, once the addressee understands the point, a system needs to be able to argue for or against that point.

A number of researchers have investigated computational models of representation and reasoning for argument. For example, Birnbaum (1982) represented propositions as nodes in an *argument graph* connected by attack and support relations. He suggested three ways to attack an argument (called *argument tactics*): attack the main proposition, attack the supporting evidence, and attack the claim that the evidence supports the main point.

In contrast, Cohen (1987) investigated the interpretation of deductive arguments and suggested how clue words (e.g., “therefore”, “and”, “so”) could be used to recognize the structure underlying arguments that are presented in “pre-order” (i.e., claim followed by evidence), “post-order” (evidence before claims), and “hybrid-order” format (using both pre-order and post-order). Reichman (1985), on the other hand, characterized natural dialogues using a number

of conversational moves (e.g., support, interrupt, challenge) indicating “clue words” such as “because”, “but anyway”, and “no but” as evidence.

In contrast, this paper extends previous research in plan-based models of communication generation (Bruce 1975, Cohen 1978, Appelt 1985, Hovy 1988, Moore & Paris, 1989, Maybury 1991ab) by formalizing a suite of communicative acts a system can use to influence user beliefs or actions. The remainder of this paper first outlines several classes of argumentative actions which are differentiated on the basis of their semantics and purpose. Next, several of these actions are formalized as plan operators. The paper then illustrates their use to improve explanations when advising an operator on a course of action during a scheduling task. The paper concludes by identifying limitations and areas for further research.

Arguments as Communicative Acts

There are many conventional patterns of argument, depending upon the goal of the speaker. Aristotle identified several methods of argument including *exemplum* (illustration), *sententia* (maxim), and *enthymeme* (a syllogism with a premise elided because it is assumed to be inferable by the addressee). An Aristotelian example of *sententia* is “No man who is sensible ought to have his children taught to be excessively clever.” Contemporary rhetoricians (e.g., Brooks & Hubbard 1905, Dixon 1987) similarly enumerate a number of general techniques which can be used to convince or persuade a hearer (e.g., tell advantages, then disadvantages). In addition to discussing general argument forms (e.g., deduction and induction), rhetoricians also indicate presentational strategies such as give the argument which will attract attention first and the most persuasive one last. While these ideas are suggestive, they are not formalized precisely enough to form the basis for a computational theory.

This paper formalizes argument as a series of communicative acts that are intended to perform some communicative goal, such as convincing an addressee to change or modify a belief, or persuading them to perform some action. For example, when attempting to change someone's beliefs, humans provide evidence, give explanations, or disprove counter-arguments to convince an addressee to believe a particular proposition. Arguments may employ descriptive or expository techniques, for

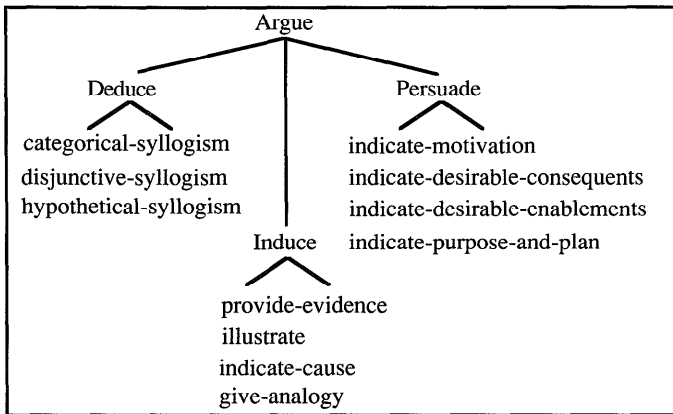


Figure 1. Communicative Acts for Argument

example to define terms (i.e., entities) or to explain propositions.

Just as humans reason about the most efficacious manner in which to achieve their goals, we have formalized and implemented a broad range of communicative acts to achieve communicative goals (Maybury 1991ab). A *communicative act* is a sequence of physical, linguistic or visual acts used to effect the knowledge, beliefs, or desires of an addressee. Linguistic acts include speech acts (Searle 1969) and surface speech acts (Appelt 1985). More abstract *rhetorical acts* coordinate linguistic and other acts. Examples include identifying an entity, describing it, dividing it (into subparts or subtypes), narrating events and situations, and arguing to support a conclusion.

Figure 1 classifies several different kinds of argumentative communicative acts. These actions can be distinguished by their purpose and semantics and are sometimes signalled by surface cues (e.g., “for example”, “because”). *Deductive arguments* such as categorical syllogism, disjunctive syllogism and hypothetical syllogism are intended to affect the beliefs of the addressee. The classic example of categorical syllogism is “All men are mortal. Socrates is a man. Therefore, Socrates is mortal.” In contrast to arguments which deduce propositions, *inductive arguments* also attempt to convince the hearer of some claim but by providing evidence and examples, or, in the broadest sense of the term, by showing cause and using analogy.

In contrast to these argumentative actions which attempt to affect the beliefs of the addressee, *persuasive argument* has the intention of affecting the goals or plans of the addressee. For example, inducing action in the addressee can be accomplished by indicating (Figure 1):

- the motivation for an act, or its purpose or goal
- the desirable consequents of performing an act
- the undesirable consequents caused by not performing an act
- how the act fits into some more general plan
- how the act enables some important/desirable act or state

Finally, there are many equally effective but perhaps less ethical methods of encouraging action such as threat, coercion, or appeal to authority. In the context of simulating human behavior, several implementations have investigated some of these kinds of persuasive techniques.

For example, characters in Meehan’s (1976) TALE-SPIN simulation could persuade one another to perform acts, for example, using threats. Sycara’s (1989) PERSUADER program simulated labor negotiations in which three agents (company, union, and mediator) could select from nine persuasive techniques (e.g., appeal to “status quo”, appeal to “authority”, threat) to effect other agent’s plans and goals. While these coercive techniques may be useful in simulations of human behavior, their use by an advisory system is probably not appropriate except in special cases (e.g., persuading someone to take their prescribed medicine). The next section details a plan-based approach to influencing beliefs and encouraging action in human users.

Communicative Plans to Influence Beliefs

We represent communicative actions for argumentation as operators or schemata in a plan library of a hierarchical planner (Sacerdoti 1977). Each plan operator defines the *constraints* and *preconditions* that must hold before a communicative act applies, its intended *effects* (also known as postconditions), and the refinement or *decomposition* of the act into subacts. The decomposition may have optional components. Preconditions and constraints encode conditions regarding the underlying knowledge base (e.g., is there evidence to support a given proposition), the current status of a user model (e.g., does the addressee believe some proposition), and the current status of the discourse (e.g., has a particular piece of evidence already been introduced). Constraints, unlike preconditions, cannot be achieved or planned for if they are false.

For example, the uninstantiated *argue-for-a-proposition* plan operator shown in Figure 2 is one of several methods of performing the communicative action *argue*. Plan operators are encoded in an extension of first order predicate calculus with variables italicized (e.g., *S*, *H*, and *proposition*). As defined in the *HEADER* of the plan operator, the *argue* action takes three arguments, the speaker (*S*), the hearer (*H*), and a *proposition*. Thus, provided the third argument is indeed a proposition (*CONSTRAINTS*) and the speaker understands it and wants the hearer to believe it (*PRECONDITIONS*), the speaker (*S*) will first claim the proposition, optionally explain it to the hearer (*H*) if they don’t already understand it (as indicated by the user model, examined by the constraints on the explain act), and finally attempt to convince them of its validity (*DECOMPOSITION*). The intended effect of this action is that the hearer will believe it (*EFFECTS*).

NAME	argue-for-a-proposition
HEADER	Argue(<i>S</i> , <i>H</i> , <i>proposition</i>)
CONSTRAINTS	Proposition?(<i>proposition</i>)
PRECONDITIONS	KNOW-ABOUT(<i>S</i> , <i>proposition</i>) ∧ WANT(<i>S</i> , BELIEVE(<i>H</i> , <i>proposition</i>))
EFFECTS	BELIEVE(<i>H</i> , <i>proposition</i>)
DECOMPOSITION	Claim(<i>S</i> , <i>H</i> , <i>proposition</i>) optional(Explain(<i>S</i> , <i>H</i> , <i>proposition</i>)) Convince(<i>S</i> , <i>H</i> , <i>proposition</i>)

Figure 2. Uninstantiated Argument Plan Operator

Intensional operators, such as WANT, KNOW, and BELIEVE appear in capitals. KNOW details an agent's specific knowledge of the truth-values of propositions (e.g., $\text{KNOW}(H, \text{Red}(\text{ROBIN-1}))$ or $\text{KNOW}(H, \neg \text{Yellow}(\text{ROBIN-1}))$) where truth or falsity is defined by the propositions in the knowledge base. That is, $\text{KNOW}(H, P)$ implies $P \wedge \text{BELIEVE}(H, P)$. Agents can hold an invalid belief (e.g., $\text{BELIEVE}(\text{JANE}, \text{Yellow}(\text{ROBIN-1}))$). An agent can KNOW-ABOUT an object or event (e.g., $\text{KNOW-ABOUT}(H, \text{DOG-1})$ or $\text{KNOW-ABOUT}(H, \text{MURDER-445})$) if they KNOW its characteristics, components, subtypes, or purpose (loosely, if they are "familiar" with it). KNOW-HOW indicates an agent's ability to perform an action.

A number of techniques can be used to explain a proposition. For example, one method is to simply define the predicate and terms of the proposition. For example if the claim is the proposition *Dictator(Hitler)*, then this can be explained by defining dictator and then defining Hitler. As expository techniques are beyond the scope of this paper, see Maybury (1991a) for details.

Even if the hearer understands the proposition, however, they may not believe it is true. To achieve this, the speaker must convince them of it. As indicated above, two types of reasoning can convince a hearer to believe a proposition: deduction and induction. The former moves top-down, from general truisms to specific conclusions whereas the latter builds arguments bottom-up, from specific evidence to a general conclusion. A simple deductive technique is to provide evidence for the proposition. Figure 3 illustrates a slightly more sophisticated deductive technique implemented to support a medical diagnostic application. This first explains how a particular situation could be the case (by detailing the preconditions, motivations, and causes of the proposition) and then informs the hearer of any evidence supporting the proposition (optionally convincing them of this). Evidence is ordered according to importance, a metric based on domain specific knowledge of the relevance and confidence of evidence.

In contrast to deductive techniques, inductive approaches can also be effective methods of convincing an addressee to believe a proposition. These include the use of illustration, comparison/contrast and analogy. For example, you can support a claim that American academics are devalued by comparing American and Japanese education to highlight America's low valuation of the teaching profession. In contrast to this comparison, analogy entails comparing the proposition, P (which we are trying to convince the hearer to believe) with a well-known proposition, Q, which has several properties in common with P. By showing that P and Q share properties α and β , we can claim by analogy that if Q has property χ , then so does P. Maybury (1991c) details similarity algorithms that are used to support this.

Preference Metrics for Argument Choice

Because there may be many methods of achieving a given goal, those operators that satisfy the constraints and essential preconditions are prioritized using *preference metrics*. For example, operators that utilize both text and graphics are preferred over simply textual operators

NAME	convince-by-cause-and-evidence
HEADER	Convince(<i>S, H, proposition</i>)
CONSTRAINTS	Proposition?(<i>proposition</i>) \wedge $\exists x \mid \text{Cause}(x, \text{proposition}) \wedge$ $\exists x \mid \text{Evidence}(\text{proposition}, x)$
PRECONDITIONS	$\exists x \in \text{evidence}$ $\neg \text{KNOW-ABOUT}(H, \text{Evidence}(\text{proposition}, x))$
EFFECTS	$\forall x \in \text{evidence}$ $\text{KNOW-ABOUT}(H, \text{Evidence}(\text{proposition}, x))$
DECOMPOSITION	Explain-How(<i>S, H, proposition</i>) $\forall x \in \text{evidence}$ $\text{Inform}(S, H, \text{Evidence}(\text{proposition}, x))$ optional (Convince(<i>S, H, x</i>))
WHERE	<i>evidence</i> = order-by-importance($\forall x \mid \text{Evidence}(\text{proposition}, x) \wedge$ $\text{BELIEVE}(S, \text{Evidence}(\text{proposition}, x))$)

Figure 3. Uninstantiated Convince Plan Operator

(Maybury 1991b). Also, those operators with fewer subgoals are preferred (where this does not conflict with the previous preference). The preference metric prefers plan operators with fewer subplans (cognitive economy), with fewer new variables (limiting the introduction of new entities in the focus space of the discourse), those that satisfy all preconditions (to avoid backward chaining for efficiency), and those plan operators that are more common or preferred in naturally-occurring explanations (e.g., rhetoricians prefer deductive arguments over inductive ones). While the first three preferences are explicitly inferred, the last preference is implemented by the sequence in which operators appear in the plan library.

Working from this prioritized list of operators, the planner ensures preconditions are satisfied and tries to execute the decomposition of each until one succeeds. This involves processing any special operators (e.g., optionality is allowed in the decomposition) or quantifiers (\forall or \exists) as well as distinguishing between subgoals and primitive acts. For example, if the planner chooses the plan operator in Figure 2 from those that satisfy its constraints, it first ensures its preconditions hold (i.e., the user knows about or "understands" the proposition), which may require backward chaining.

Communicative Plans to Evoke Action

While different forms of argument such as deduction and induction can be belief or action-oriented, the previous sections have defined deductive and inductive forms narrowly as primarily affecting hearer beliefs; this section will similarly define persuasive techniques in the narrow sense as primarily affecting hearer actions. (Of course in the act of convincing someone to believe a proposition using deductive or inductive techniques you can also persuade them to act. Similarly, in the course of persuading someone to act you can change their beliefs.) The following invitation exemplifies arguments that encourage action:

Come to my party tonight. It's at 1904 Park Street. We are serving your favorite munchies and we have plenty of wine and beer. Everybody is going to be there. You'll have a great time.

This text tells the reader what to do, enables them to do it, and indicates why they should do it. This common communicative strategy occurs frequently in ordinary texts intended to get people to do things. It consists of *requesting* them to do the act (if necessary), *enabling* them to do it (if they lack the know-how), and finally *persuading* them that it is a useful activity that will produce some desirable benefit (if they are not inclined to do it). In the above example, the action coming to the party, is enabled by providing the address. The action is motivated by the desirable attributes of the party (i.e., tasty munchies and abundant supply of liquor), the innate human desire to belong, and by the desired consequence of coming to it (i.e., having fun).

This general strategy corresponds to the *request-enable-persuade* plan operator shown in Figure 4. The operator gets the hearer to do some action by requesting, enabling, and then persuading them to do it. *Enable*, the second communicative act in its decomposition, refers to communicative actions which provide the addressee with enough know-how to perform the action (see Maybury 1991a for details). The plan operator in Figure 4 distinguishes among (1) the hearer's knowledge of how to perform the action (i.e., KNOW-HOW, knowledge of the subactions of the action) (2) the hearer's ability to do it (ABLE), and (3) the hearer's desire to do it (WANT). For example, the hearer may want and know how to get to a party, but they are not able to come because they are sick. If the speaker knows this, then they should not use the plan operator below because its constraints fail. The assumption is that a general user modelling/acquisition component will be able to provide this class of information.

NAME	request-enable-persuade
HEADER	Argue(<i>S, H, Do(H, action)</i>)
CONSTRAINTS	Action?(<i>action</i>) \wedge ABLE(<i>H, action</i>)
PRECONDITIONS	WANT(<i>S, Do(H, action)</i>)
EFFECTS	KNOW(<i>H, WANT(S, Do(H, action))</i>) \wedge KNOW-HOW(<i>H, action</i>) \wedge WANT(<i>H, Do(H, action)</i>) \wedge Do(<i>H, action</i>)
DECOMPOSITION	Request(<i>S, H, Do(H, action)</i>) Enable(<i>S, H, Do(H, action)</i>) Persuade(<i>S, H, Do(H, action)</i>)

Figure 4. request-enable-persuade Plan Operator

The order and constituents of a communication that gets an individual to act, such as that in Figure 4, can be very different indeed depending upon the conversants involved, their knowledge, beliefs, capabilities, desires, and so on. Thus to successfully get a hearer to do things, a speaker needs to reason about his or her model of the hearer in order to produce an effective text. For example, in an autocratic organization, a request (perhaps in the linguistic form of a command) is sufficient. In other contexts no request need

be made because the hearer(s) may share the desired goal, as in the case of the mobilization of the Red Cross for earthquake or other catastrophic assistance. Similarly, if the hearer wants to do some action, is able to do it, and knows how to do it, then the speaker can simply ask them to do it. Because the hearer is able to do it, the speaker need not enable them. And because the hearer wants or desires the outcome of the action, the speaker need not persuade them to do it. Thus we also represent a simple *request* plan operator which argues that the hearer perform an action by simply asking them to do it. A variation on this plan operator could model delegation, whereby the speaker may know the hearer is not willing to do or does know how to perform some task, but the speaker simply asks them because it is expected that they figure out how to do it. As with the autocratic example above, this would require a model of the interpersonal relations of the speaker and hearer (Hovy 1987).

In addition to a request for action, enablement may be necessary if the audience does not know how to perform the task. The following text from the NYS Department of Motor Vehicles *Driver's Manual* (p. 9) informs the reader of the prerequisites for obtaining a license:

To obtain your driver's license you must know the rules of the road and how to drive a car or other vehicle in traffic.

The writer indicates that being knowledgeable of both road regulations and vehicle operation are necessary preconditions for obtaining a license. In some situations, however, the reader may be physically or mentally unable to perform some action, in which case the writer should seek alternative solutions, eventually perhaps consoling the reader if all else fails. On the other hand, if the user is able but not willing to perform the intended action, then a writer must convince them to do it, perhaps by outlining the benefit(s) of the action. Consider this excerpt from the *Driver's Manual*:

The ability to drive a car, truck or motorcycle widens your horizons. It helps you do your job, visit friends and relatives and enjoy your leisure time.

Of course it could be that the hearer already wants to do something but does not know how to do it. In this situation a communicator must explain how to perform the action (see, for example, Moore & Paris (1989) and Maybury (1991a)). However, in some cases the addressee must be persuaded to act and so the next section formalizes several techniques to do so and illustrates their use in an advisory context.

First, however, we briefly compare the *request-enable-persuade* strategy in Figure 4 to Moore & Paris' (1989) "recommend-enable-motivate" strategy. Their plan-based system has three "motivation" strategies: motivating (by telling the purpose and/or means of an action), showing how an action is a step (i.e., subgoal) of some higher-level goal (elaborate-refinement-path), and giving evidence. Some of these techniques are domain specific (e.g., a "motivate-replace-act", where "replace" is specific to the Program Enhancement Advisor domain), and others are architecture/knowledge representation specific (e.g.,

“elaborate-refinement-path” is a technique based on the Explainable Expert System’s architecture (Neches et al. 1985)). In contrast, the strategies presented here are domain and application independent and include persuasion by showing motivation, enablement, cause, and purpose. Furthermore, they distinguish rhetorical acts (e.g., enable, persuade) from illocutionary acts (e.g., request) from surface speech acts (e.g., command, recommend) from the semantic relations underlying these (e.g., enablement, cause). Finally, this paper formalizes communicative acts for both convincing and persuading (i.e., convincing a hearer to believe a proposition versus persuading them to perform an action) and it is the latter which we now detail.

Persuasive Communicative Acts

When an addressee does not want to perform some action, a speaker must often persuade them to act. There are a variety of ways to persuade the hearer including indicating (1) the motivation for the action, (2) how the action can enable some event, (3) how it can cause a desirable outcome, or (4) how the action is a part of some overall purpose or higher level goal.

For example, the plan operator named *persuade-by-desirable-consequents* in Figure 5 gets the hearer to want to do something by telling them all the desirable events or states that the action will cause. An action can either cause a positive result (e.g., approval, commendation, praise) or avoid a negative one (avoid blame, disaster, or loss of self esteem). Advertisement often uses this technique to induce customers to purchase products by appealing to the emotional benefits (actual or anticipated) of possession. An extension of this plan operator could warn the hearer of all the undesirable events or states that would result from their inaction.

NAME	persuade-by-desirable-consequents
HEADER	Persuade($S, H, Do(H, action)$)
CONSTRAINTS	$Act(action) \wedge \exists x \mid Cause(action, x)$
PRECONDITIONS	$\neg WANT(H, Do(H, action))$
EFFECTS	$WANT(H, Do(H, action)) \wedge$ $\forall x \in desirable-events-or-states$ $KNOW(H, Cause(action, x))$
DECOMPOSITION	$\forall x \in desirable-events-or-states$ $Inform(S, H, Cause(action, x))$
WHERE	$desirable-events-or-states =$ $\{x \mid Cause(action, x) \wedge WANT(H, x)\}$

Figure 5. persuade-by-desirable-consequents Plan Operator

Some actions may not cause a desirable state or event but may enable some other desirable action (that the hearer or someone else may want to perform). For example, in the NYS driving example, obtaining a license is a precondition of driving a car, which enables you to visit friends, go shopping, etc. This plan could also be extended to warn the hearer of all the undesirable events or states that would be enabled by their inaction.

NAME	persuade-by-purpose-and-plan
HEADER	Persuade($S, H, Do(H, action)$)
CONSTRAINTS	$Act(action)$
PRECONDITIONS	$\neg WANT(H, Do(H, action))$
EFFECTS	$WANT(H, Do(H, action)) \wedge$ $KNOW(H, Purpose(action, goal))$
DECOMPOSITION	$Inform(S, H, Purpose(action, goal))$ $Inform(S, H, Constituent(plan, action))$
WHERE	$goal = g \mid Purpose(action, g) \wedge WANT(H, g)$ $plan = p \mid Constituent(p, action) \wedge$ $WANT(H, Do(p))$

Figure 6. persuade-by-purpose-and-plan Plan Operator

One final form of persuasion, *persuade-by-purpose-and-plan*, shown in Figure 6, gets the hearer to perform some action by indicating its purpose or goal(s) and how it is part of some more general plan(s) that the hearer wants to achieve. For example, one subgoal of shopping is writing a check, an action which has the effect or purpose of increasing your liquid assets. These operators give a range of persuasive possibilities. The next section illustrates their application in the context of a cooperative problem solver.

Persuasion in Collaborative Planning

The persuasive plan operators described above (i.e., indicating motivation, enablement, cause, or purpose) were tested using the cooperative Knowledge based Replanning System, KRS (Dawson et al. 1987), a resource allocation and scheduling system. KRS is implemented in a hybrid of rules and hierarchical frames. KRS employs meta-planning (Wilensky 1983) whereby high-level problem solving strategies govern lower-level planning activities. Therefore, it can justify its actions by referring to the higher level strategy it is employing.

Figure 7 illustrates these strategies (e.g., plan an air tasking order, replan an air tasking order, replan an attack mission, and so on) which govern lower-level planning activities (e.g., prescan a package of missions, plan a package of missions, plan an individual mission, and so on). Associated with each meta-plan shown in Figure 7 are several types of information including its name, type, purpose, subgoals, relations among subgoals (e.g., enablement, sequence, etc.), planning history, associated entities (e.g., the name of the mission being replanned), and failure handlers. Therefore when the actions encoded by the plans are executed, the meta-planner knows why particular actions occur when they do. For example, if the user is not persuaded that scanning a plan is a useful activity and they may ask “Why is scanning the plan necessary?” (simulated by posting the action *PERSUADE* ($\#<SYSTEM>$, $\#<USER>$, $Do(\#<SYSTEM>$, $\#<PRESCAN-ATO>$)). To achieve this action, our explanation planner uses the *persuade-by-purpose-and-plan* operator of Figure 6. This examines the meta-plan structure and produces the response shown in Figure 8 (the surface speech acts, *assert*, which realize the inform acts, are elided). Maybury (1991d) details the linguistic realizer.

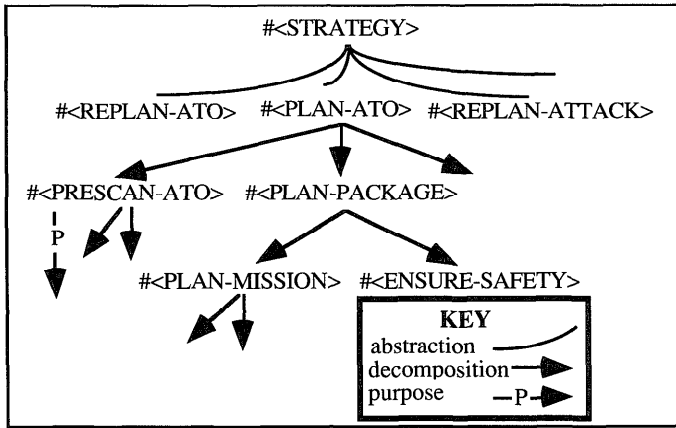


Figure 7. Structure of Plans and Meta-Plans in KRS

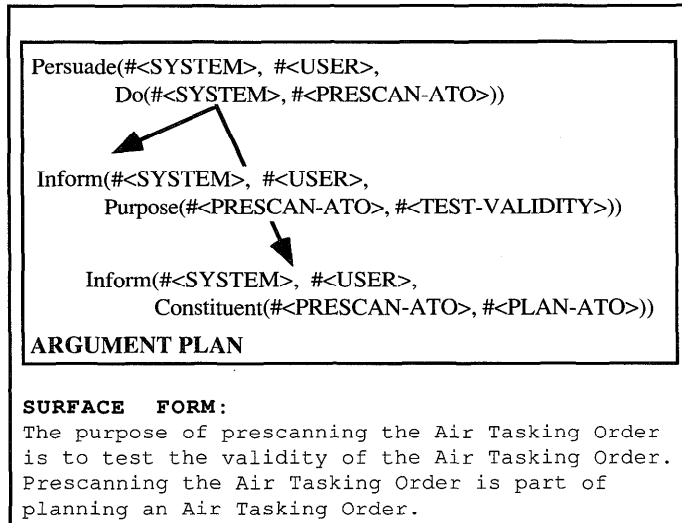


Figure 8. Argument in support of a Domain Action

Just as showing how an action supports some more general plan or goal can support that action, another way to persuade an addressee to perform (or support) an action is to indicate the cause and/or motivation for the action. Because KRS is a mixed-initiative planner, it cooperates with the user to produce an Air Tasking Order, a package of air missions (e.g., reconnaissance, refueling, escort) that achieve some desired goal (e.g., defend friendly territory). Because of this multi-agent problem solving, the system and user can make choices which result in an ill-formed mission plan. If directed by the user, KRS can replan such an ill-formed mission plan using dependency-directed backtracking (e.g., making changes in the plan by reasoning about temporal and spatial relationships). KRS initially attempts to retract system-supplied choices. As a last resort, KRS suggests to the user that they remove user-supplied choices to recover from the ill-formed plan. In this case the system tries to justify its recommendation on the basis of some underlying rule governing legal plans.

For example, assume the user has interacted with the system to produce the mission shown in Figure 9 (simplified for readability). The frame, OCA1002, is an offensive counter air mission, an instance of (AIO) the class offensive counter air (OCA), with attributes such as a type and number of aircraft, a home airbase, and a target. Each attribute encodes actual and possible values as well as STATUS slot which indicates who supplied the value (e.g., user, planner, meta-planner). Frames also record interactional information, for example in Figure 9 the HISTORY slot records that the user just selected a target and the WINDOW slot indicates where the mission plan is visually displayed. KRS represents domain-dependent relations among slots so that values for some of the slots can be automatically calculated by daemons in reaction to user input (e.g., when the UNIT and ACNUMBER slot of a mission are filled in, the CALL-SIGN slot can be automatically generated).

During planning the system monitors and detects ill-formed mission plans by running rule-based diagnostic tests on the mission plan. For example, in Figure 9 the offensive counter air mission has an incompatible aircraft and target. KRS signals the constraint violation by highlighting the conflicting slots (e.g., AIRCRAFT and TARGET) of the mission frame which is represented visually in a mission window to the user. The built-in explanation component would then simply state the rule-based constraint which detected the error in the mission plan, and then list some of the supporting knowledge (see Figure 10). The first two sentences of the explanation in Figure 10 are produced using simple templates (canned text plus variables for the mission (OCA1002), rule name (TARGET-AIRCRAFT-1), and conflicting slots (TARGET and AIRCRAFT)). The list 1-4 is simply a sequence of information supporting the constraint violation although

(OCA1002	(VALUE	(OCA)))
(AIO	(POSSIBLE	((F-4C F-4D F-4E F-4G F-111E F-111F)))
(AIRCRAFT	(VALUE	(F-111E))
	(STATUS	(USER)))
(TARGET	(VALUE	(BE30703))
	(STATUS	(USER)))
(ACNUM	(POSSIBLE	((1 2 ... 25)))
	(VALUE	(3))
	(STATUS	(USER)))
(AIRBASE	(POSSIBLE	((ALCONBURY)))
(ORDNANCE	(POSSIBLE	((A1 A2 ... A14)))
(HISTORY	(VALUE	(#<EVENT INSERT TARGET BE30703 USER>)))
(DISPLAY	(VALUE	(#<MISSION-WINDOW 1 1142344 deexposed>)))

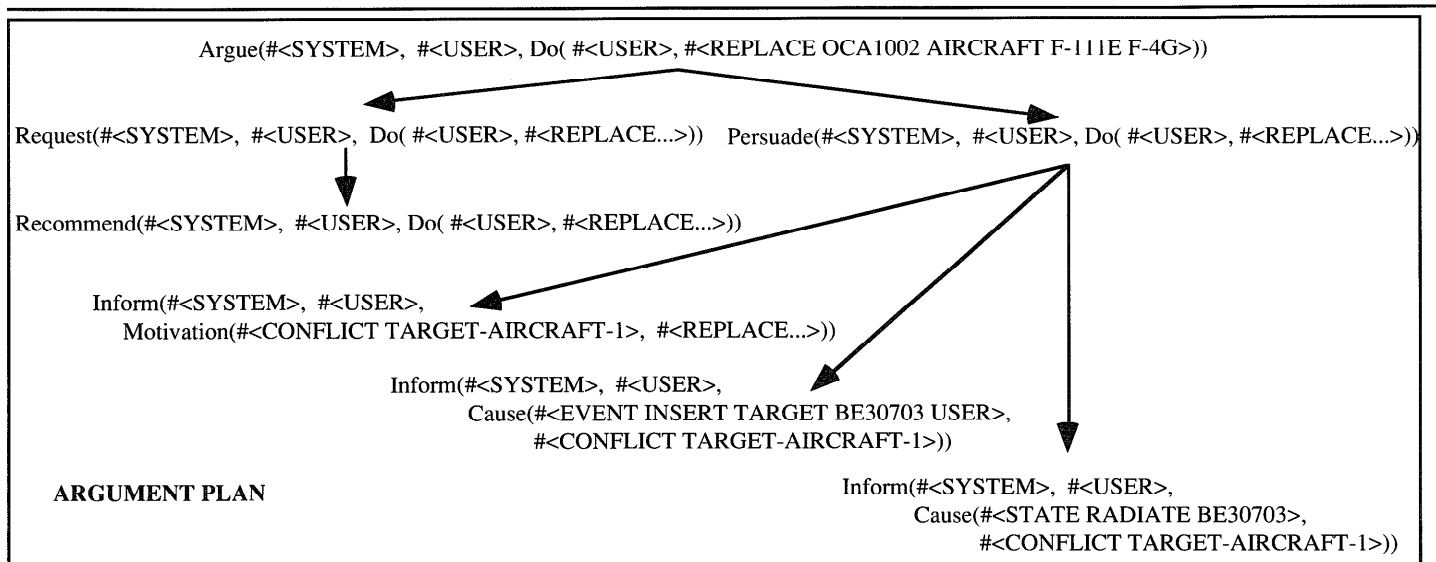
Figure 9. Simplified Mission Plan in FRL

The choice for AIRCRAFT is in question because:

BY TARGET-AIRCRAFT-1: THERE IS A SEVERE CONFLICT BETWEEN TARGET AND AIRCRAFT FOR OCA1002

1. THE TARGET OF OCA1002 IS BE30703
2. BE30703 RADIATES
3. THE AIRCRAFT OF OCA1002 IS F-111E
4. F-111E IS NOT A F-4G

Figure 10. Current Explanation of Rule Violation



SURFACE FORM:

You should replace F-111e aircraft with F-4g aircraft in Offensive Counter Air Mission 1002. A conflict between the aircraft and the target in Offensive Counter Air Mission 1002 motivates replacing F-111e aircraft with F-4g aircraft. You inserted BE30703 in the target slot and BE30703 was radiating which caused a conflict between the aircraft and the target in Offensive Counter Air Mission 1002.

Figure 11. Argument to Encourage User to Act -- Initiated by Rule Violation

there is no indication as to how these relate to each other or to the rule. The fact that BE30703 (Battle Element 30703) is radiating indicates that it is an operational radar. KRS expects domain users (i.e., Air Force mission planners) to know that only anti-radar F-4g ("Wild Weasel") aircraft fly against these targets. Rather than achieving organization from some model of naturally occurring discourse, the presentation in Figure 10 is isomorphic to the underlying inference chain. Because the relationships among entities are implicit, this text lacks cohesion. More important, it is not clear what the system wants the user to do and why they should do it.

In contrast, our text planner was interfaced to KRS by relating rhetorical predicates (e.g., cause, motivation, attribution) to the underlying semantic relations of the domain embodied both in rules justifying constraint violations and in frames representing the mission plan and other domain entities (e.g., aircraft and target frames). Unlike the template and code translation approach used to produce the text in Figure 10, now KRS posts the action *ARGUE*(#<SYSTEM>, #<USER>, *Do*(#<USER>, #<REPLACE OCA1002 AIRCRAFT F-111E F-4G>)) to the text planner. The text planner then instantiates, selects and decomposes plan operators similar to the one in Figure 5 to generate the argument plan and corresponding surface form shown in Figure 11. The output is improved not only by composing the text using communicative acts, but also by linguistic devices, such as the lexical realization "Offensive Counter Air Mission 1002" instead of OCA1002 as well as verb choice, tense and aspect (e.g., "should replace", "inserted"). For example, the recommended

surface speech act is realized using the obligation modal, "should". As above, assertions, the surface speech acts for inform actions, are elided from the argument plan. Finally, note how the surface realizer joins the final two informs into one utterance because they have similar propositional content (i.e., causation of the same conflict).

Conclusion and Future Directions

Argument, perhaps the most important form of communication, enables us to change other's beliefs and influence their actions. This paper characterizes argument as a purposeful communicative activity and formalizes argumentative actions (e.g., deduce, induce, persuade) as plans, indicating their preconditions, constraints, effects, and decomposition into more primitive actions. We illustrate how these plans have been used to improve a communicative interface to a cooperative problem solver.

As the focus of the paper is on the presentation of arguments (i.e., their form), we make no claims regarding their representation, including associated inference or reasoning strategies. Furthermore, no claims are made concerning the representation of intentions and beliefs. Indeed, an important issue that remains to be investigated is how content and context modifies the effect of different communicative plans (e.g., deduction can both change beliefs and move to action depending upon context). This seems analogous to the alteration of the force of illocutionary speech acts by variation in syntactic form or intonation.

Another unresolved issue concerns the multi-functional nature of communicative acts and their interaction. This is

more complicated than representing multiple effects of actions, as do our plans. For example, the advertisement below compels the reader to action using a variety of techniques including description, comparison, and persuasion.

Buy Pontiac. We build excitement. The new Pontiacs have power brakes, power steering, AM/FM stereos, and anti-lock brakes. And if you buy now, you will save \$500. An independent study shows that Pontiacs are better than Chevrolet. See your Pontiac dealer today!

In this example, the initial request for action (i.e., purchase) is supported by indicating the desirable attributes of the product, the desirable consequences of the purchase, comparing the action with alternative courses of action/competing products, and finally imploring the hearer to act again. While some of these techniques may be implemented as plan operators in a straightforward manner (e.g., describe desirable attributes), the interaction of various text types remains a complex issue. For example, how is it that some texts can persuade by description, narration or exposition, and entertain by persuasion? What also remains to be investigated is the relationship of linguistic and visual acts to influence beliefs or actions, as in advertisement.

Acknowledgements

I want to thank Karen Sparck Jones and John Levine for detailed discussions on explanation and communication as action.

References

- Aristotle. 1926. *The 'Art' of Rhetoric*. trans. J. H. Freese, Cambridge, MA: Loeb Classical Library series.
- Appelt, D. 1985. *Planning English Sentences*. England: Cambridge University Press.
- Birnbaum, L. 1982. Argument Molecules: A Functional Representation of Argument Structure. In *Proceedings of the Third National Conference on Artificial Intelligence*, 63-65. Pittsburg, PA: AAAI.
- Brooks, S. D. and Hubbard, M. 1905. *Composition Rhetoric*. New York: American Book Company.
- Bruce, B. C. 1975. Generation as a Social Action. In *Proceedings of Theoretical Issues on Natural Language Processing-1*, 64-67. Urbana-Champaign: ACL.
- Cohen, P. R. 1978. On Knowing What to Say: Planning Speech Acts. University of Toronto TR-118.
- Cohen, R. 1987. Analyzing the Structure of Argumentative Discourse. *Computational Linguistics* 13(1-2):11-23.
- Dawson, B.; Brown, R.; Kalish, C.; & Goldkind, S. 1987. Knowledge-based Replanning System. RADC TR-87-60.
- Dixon, P. 1987. *Rhetoric*. London: Methuen.
- Hovy, E. 1987. Generating Natural Language Under Pragmatic Constraints. Ph.D. diss., Dept. of Computer Science, Yale University TR-521.
- Hovy, E. 1988. Planning Coherent Multisentential Text. In *Proceedings of the 26th Annual Meeting of the ACL*, 163-169. Buffalo, NY: ACL.
- Maybury, M. T. 1991a. Generating Multisentential English Text Using Communicative Acts. Ph.D. diss., Computer Laboratory, Cambridge University, England, TR-239. Also available as RADC TR 90-411.
- Maybury, M. T. 1991b. Planning Multimedia Explanations Using Communicative Acts. In *Proceedings of the Ninth National Conference on Artificial Intelligence*, 61-66. Anaheim, CA: AAAI.
- Maybury, M. T. 1991c. Generating Natural Language Definitions from Classification Hierarchies. In *Advances in Classification Research and Application: Proceedings of the 1st ASIS Classification Research Workshop*, ed. S. Humphrey. ASIS Monographs Series. Medford, NJ: Learned Information.
- Maybury, M. T. 1991d. Topical, Temporal, and Spatial Constraints on Linguistic Realization. *Computational Intelligence* 7(4):266-275.
- McKeown, K. 1985. *Text Generation*. Cambridge University Press.
- Moore, J. D. and C. L. Paris. 1989. Planning Text for Advisory Dialogues. In *Proceedings of Twenty-Seventh Annual Meeting of the ACL*, 203-211, Vancouver.
- Neches, R.; Moore, J.; & Swartout, W. November 1985. Enhanced Maintenance and Explanation of Expert Systems Through Explicit Models of Their Development. *IEEE Transactions on Software Engineering* SE-11(11):1337-1351.
- Paris, C. 1987. The Use of Explicit User Models in Text Generation: Tailoring to a User's Level of Expertise. Ph.D. diss., Dept. of Computer Science, Columbia University.
- Reichman, R. 1985. *Getting Computers to Talk Like You and Me*. Cambridge, MA: MIT Press.
- Sacerdoti, E. D. 1977. *A Structure for Plans and Behavior*. New York: Elsevier North-Holland. (Originally SRI TN-109, 1975.)
- Searle, J. R. 1969. *Speech Acts*. Cambridge University Press.
- Toulmin S.; Rieke, R.; & Janik, A. 1979. *An Introduction to Reasoning*. New York: Macmillan.
- Wilensky, R. 1983. *Planning and Understanding*. Reading, MA: Addison-Wesley.
- Meehan, J. R. 1977. TALE-SPIN, an Interactive Program that Writes Stories. In *Proceedings of Fifth International Joint Conference on Artificial Intelligence*, 91-98.
- Sycara, K. 1989. Argumentation: Planning Other Agents' Plans. In *Proceedings of the Eleventh International Joint Conference on Artificial Intelligence*, 517-523.