Mediating Between Hearer’s and Speaker’s Views in the Generation of Adaptive Explanations

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Abstract—In this article, we examine the case of a system that cooperates with a “direct” user to plan an activity that some “indirect” user, not interacting with the system, should perform. The specific application we consider is the prescription of drugs. In this case, the direct user is the prescriber and the indirect user is the person who is responsible for performing the therapy. Relevant characteristics of the two users are represented in two user models. Explanation strategies are represented in planning operators whose preconditions encode the cognitive state of the indirect user; this allows tailoring the message to the indirect user’s characteristics. Expansion of optional subgoals and selection among candidate operators is made by applying decision criteria represented as metarules, that negotiate between direct and indirect users’ views also taking into account the context where explanation is provided. After the message has been generated, the direct user may ask to add or remove some items, or change the message style. The system defends the indirect user’s needs as far as possible by mentioning the rationale behind the generated message. If needed, the plan is repaired and the direct user model is revised accordingly, so that the system learns progressively to generate messages suited to the preferences of people with whom it interacts.

1. INTRODUCTION

RECENT APPROACHES to text generation (Andre & Rist, 1992; Mittal & Paris, 1993) distinguish between messages corresponding to different roles played by system and user (monologue vs. dialogue), having different purposes (explanation vs. critique), and using different communication means (linguistic vs. multimedia acts). Several aspects of the text vary according to these conditions: the discourse structure, the tone of interaction, and, consequently, the rhetorical techniques and the communication means used. The need to adapt the message to the intended hearer is also recognized as essential, to ensure that the message achieves its purpose. When the message is a dialogue, information collected during the interaction can help in understanding the hearer needs and in revising the message accordingly. Thus, one can start with an incomplete and approximate model of the hearer, and use hearer feedback to build a progressively more realistic image of his or her characteristics.

The above experiences all relate to a situation where the system plays the role of the main speaker and the user is the target of the message, that is, the hearer. The user can then intervene in the dialogue by asking for more explanation or clarification, or by critiquing the system’s statements. But, let us consider the case of a message that is generated by the system to be addressed to a person who does not interact with the system itself. Furthermore, let us suppose that the person who is responsible for delivering the message interacts with the system and is, therefore, able to control the message, to validate it. The two users’ views on what the message should contain and how it should be formulated will presumably differ. In generating the message, the system will, therefore, have to ensure that
the text produced is acceptable to both of them: to do this, it will have to know the main characteristics of both users and will have to adapt the text accordingly, by finding the best compromise between their views.

We have studied this problem in the context of a knowledge based system on drug prescription (Optimization of drug Prescription using ADvancEd informatics [OPADE]). The user who interacts with this system is the drug prescriber (usually, a physician), whereas the person to whom the message is addressed is someone who is responsible for performing the therapy. This could be the patient, a nurse, a prescriber’s colleague, or the general practitioner. The message consists of a set of instructions concerning the drug therapy, and its role is to provide the hearer with information needed to perform this therapy correctly. To be really useful to the physician, the text has to be generated by minimizing the physician intervention. It is thus, essentially, an argumentative discourse, and a monologue. However, the physician is allowed to object to the computer-generated text, and the system will try to defend its choice by entering into negotiation with the physician, and will revise the text if needed. As compared with previous studies, then, the hearer of the message is what we call the indirect user (because he/she does not interact with the system), whereas the speaker is the physician (the direct user) and the system plays the role of a scribe who is aware of both users’ needs.

2. THE CONTEXT

2.1 The Application Domain

The objective of OPADE is to improve the quality of drug treatment by supporting the physician in the prescription process and by increasing compliance with the therapy. To do this, OPADE makes available to the prescribing physician detailed, up-to-date information on all drugs within the European Community; it also suggests alternative, cheaper generics if they exist, and checks that some “principles of therapeutics” are not violated. As OPADE plays the role of an expert critiquing system, the first and the final decisions are always left to the prescriber. To increase compliance, the health personnel who are responsible for patient care during the hospital stay (nurses or prescriber’s colleagues) have to know the therapy and how to perform it. Similarly, when the patient is discharged, the general practitioner and the patient or his/her family have to know all the information that is relevant for a correct application of the therapy. Other researchers have studied the problem of improving information exchange between physicians and other actors in the health care process, in particular patients (Buchanan, Moore, Forsythe, Banks, & Ohlsson, 1993). They have proposed that patients should be given the possibility of interacting with the computer, in order to obtain explanations and to ask specific questions, when these are not sufficiently clear or complete. We are convinced that this solution is not immediately practicable in most European contexts. Given that the objective of the OPADE project is to produce and evaluate a system prototype before 1995, we have decided to generate a written explanation that will be attached to the prescription, tailored to the user to whom it is addressed. However, this should not necessarily be considered to be a negative aspect of the system. Written explanations also have the advantage that they can be reread, for example when the patient returns home.

2.2. The Knowledge Sources

The knowledge base on drugs is the core of OPADE. It is made up of two components (OPADE, 1993):

- A European object oriented database on drugs, which is created at an international level from existing drug databanks, and is updated with national and local information. Each drug in the database is described by several attributes (commercial name, therapeutic class, expected effect, side effects, contraindications, etc. . .).
- A set of principles of therapeutics. These rules are the core of the expert critiquing system. An example is, “avoid prescribing two or more drugs belonging to the neuroleptics therapeutic class.”

Terms used during the prescription process and their links are represented in a multilingual thesaurus. In addition to this general knowledge, information about the specific patient and the specific drug treatment are stored in two case-specific knowledge sources:

- A patient model, which includes identification data and the main environmental, physiological, and pathological variables that might influence the drug prescription (socioeconomic status, main diseases and symptoms, etc. . .). These data are derived from the database of medical records to which OPADE is linked.
- A prescription record, which includes a list of drugs prescribed, with the directions for administration (dosage, route of administration, intake modalities, etc. . .).
3. EXPERIMENTAL BASIS FOR TEXT GENERATION

Two studies guided us in understanding what direct and indirect users would like to see in an explanation attached to a prescription for medication. The first study was an analysis of the information needs of indirect users (patients and nurses). The second study examined how direct users would explain to indirect users a prescription for medication for specific clinical cases. These studies are described in detail elsewhere (Berry, Gillie, & Banbury, 1995; OPADE, 1993). We will report here only the main issues that are relevant for the generation of explanations to patients and nurses.

3.1. Study One: Analysis of Information Needs of Indirect Users

3.1.1. What do patients want to know. Berry, Gillie and Banbury (1995) report three studies investigating what patients would like to know about the medication they are prescribed. In their first study, people were presented with a hypothetical scenario about a visit to the doctor and were asked to write down the questions they would like to ask the doctor about the prescribed medication. Twenty question categories were identified and ranked in order of frequency of occurrence. Table 1 shows the top 12 question categories in order of frequency of occurrence.

3.1.2. What do nurses want to know. A similar study was carried out with nurses (OPADE, 1993). In this case, nurses were presented with one of four hypothetical scenarios describing a patient who had been admitted onto their ward and had been prescribed a drug with which they were not familiar. For example: “An elderly gentleman has been admitted to your ward with abdominal pain. He has a past history of heart failure and diabetes, and is taking regular medication for these. He may need surgical intervention at some stage. He has been prescribed a drug for the abdominal pain that you are not familiar with.” The nurses were asked to write down the questions they would like to ask the doctor about the prescribed medication, as well as what other actions they would take. Again, 12 question categories were identified and ranked in order of frequency of occurrence. Table 1 shows the 12 question categories in order of frequency of occurrence.

The frequency with which particular questions were asked gave us a measure of the importance attached to the questions by the two categories of indirect users. We called these “ratings of importance to indirect users” (RII). As would be expected from Table 1, there were some differences in the ratings for the two classes of indirect user. While both patients and nurses asked questions about side effects and information about the medication (what it does and how it works), the nurses were very concerned with details about the drug administration and which observations to make or associated actions to take. Some items requested by the patients were completely absent from the nurses list; for example, questions about lifestyle changes, alternatives to the medication, and risks of not taking the medication.

3.2. Study Two: How Doctors Explain Their Prescription; Analysis of Transcripts

The purpose of this second study (also reported in OPADE, 1993) was to investigate how direct users (physicians) explain their prescriptions to certain classes of indirect user (colleague, patient, nurse). A preliminary study was carried out in Italy with pediatricians. A follow-up study was then conducted in the UK with cardiologists and other physicians. In these studies, doctors were presented with a hypothetical scenario about a patient and were asked to make a prescription and then provide an explanation of this prescription aimed at different classes of indirect user. Four scenarios were used in the Italian study and a different four in the UK study. An example of one of the UK scenarios is as follows:
"A 62-year-old man complains of central chest pain, radiating to the left shoulder and arm. The pain occurs on climbing steep slopes or more than two flights of stairs. He does not have to do either of these frequently, and can walk at least three miles on the flat without difficulty. If the pain does occur, it will disappear after a couple of minutes rest. He is otherwise very well, and is not unduly worried about his symptoms. Tests confirm coronary disease but no other specific clinical abnormalities. The patient has been diagnosed as suffering from exercise induced angina in a mild form."

A total of 69 explanations (in the two studies) were collected from 15 doctors overall. The explanations were tape recorded and subsequently transcribed.

An advantage of using these hypothetical scenarios is that it is possible to exert control over the data gathering process. The same scenario can be presented to more than one doctor, and each doctor can be asked to provide explanations for specific types of indirect user. Of course, one can argue that this is a rather unnatural situation. However, most of the doctors commented that they found it a fairly natural procedure. This was also evident in their transcripts where it can be seen that some doctors added in additional information about the hypothetical patients. For example, one doctor started his explanation to a nurse in the following way: "I wonder if you could take care of this pleasant 62-year-old gentleman."

The explanations provided by the doctors varied according to several factors: the doctor, the expected hearer, and the clinical context. We examined each text in terms of communicative actions and of rhetorical structure (Grosz & Sidner, 1986; Mann, Matthiesen, & Thompson, 1989). Although there was a constant plot of communicative actions used in the various texts, and some recurrent rhetorical techniques, there were a lot of differences between the texts. These were presumably due to differences in the assumptions that each doctor made about the hearer’s knowledge, goals, and role in the drug treatment process. A synthetic description of differences in the frequencies with which particular information items were mentioned in explanations addressed to patients and nurses can be found in Table 2. Explanations to patients were, in general, more detailed, especially in relation to drug administration. Nurses were informed about the patient’s general condition and were instructed more carefully about monitoring/observation actions.

Let us now examine two examples in detail. Figures 1 and 2 show explanations (with their pattern of action goals) relating to the case described in the above scenario, which are addressed to a patient and to a nurse, respectively. Figures 3 and 4 show the rhetorical structure of the same texts of figures 1 and 2, respectively. In the formalization of communicative actions in Figures 1 and 2, the argument "indirect user" is omitted, as all acts (to explain, to describe, and so on) are addressed to the indirect user.

There are links between the hierarchies of actions and of rhetorical relations. For example, in the explanation to the patient (Figure 1), the action IO: (Explain the drug prescription) is decomposed in two main actions II, I2-I3: (Describe the health state of the patient) and (Expose the treatment plan). II and I3 refer, respectively, to discourse segments DS1 and DS3, the first one relating to utterances 1 to 3C, and the second one to utterances from 4 on. These two text spans are linked by a rhetorical relation of solutionhood (Figure 3), whose satellite is DS1 and whose nucleus is DS3. The linkage between the two text spans is marked by the cue phrase 3DE which, at the same time, synthesizes the treatment plan: “but I do think we should treat it, and I’d like to give you three separate drugs for this.” In other cases, this relationship is implicit. For example, in the explanation to the nurse (Figure 4), DS1 is the satellite and DS2 is the nucleus of the solutionhood; however, no linguistic marker denotes this relation.

The message is tailored to the indirect user and to the clinical context by varying both discourse features. First, by changing the pattern of communicative acts, one details differently the various aspects of the explanation. Second, by changing the rhetorical structure, one achieves the same intention by using different arguments. Let us look again at examples 1 and 2.

3.2.1. Communicative acts. The first part of the explanation to the patient (DS1 in Figure 1) is aimed at describing his health state (II) by describing both his clinical situation (I4, DS4) and the presumed severity of this situation (I6, DS6). To convince the hearer of the diagnosis, just a generic sentence (“your tests have come back”) is used; in other cases, the list of symptoms and/ or tests that support the diagnosis is provided. The disease is defined by illustrating its pathophysiological characteristics (I5, DS5). When explaining the same case to the nurse (Figure 4), the name of the disease with its severity is considered as sufficient. The doctor does not consider it necessary to persuade the nurse about the diagnosis or to give a definition of the disease. Probably, he/she is
convincing that the nurse already knows the concept and has confidence in his/her diagnostic decision. A more limited use of the “persuasion” communicative goal is made in explanations addressed to the nurse than in explanations to the patient. For example, the segment 4E in Figure 3: “this has been shown to reduce the chance of you having a heart attack with your angina,” which is aimed at persuading the patient about the desirable consequences of taking the first drug by describing its beneficial effects, has no correspondent in Figure 4. Instructions about administration of simple drugs, which are given to the patient (utterances 4CD) are also omitted from explanations to the nurse, as the doctor presumes that the nurse already knows them. However, action goals in the nurse explanations are not simply a subset of those in the patient explanations: some of them such as exposing revisions to be made in the therapy (I6), or controls (17) are introduced only in the nurse message.

Drawing this together, we can say that explanations given by doctors have an overall structure that can be represented by a hierarchy of communicative actions. Each action goal in the hierarchy can be assigned a rating of importance—to the doctor (RID): some goals are essential, and, therefore, are introduced in all explanations; others are optional, and are introduced only by some doctors and in some cases. For example, the information content of explanations addressed to patients is different from the content of those addressed to nurses. It varies, as well, according to the doctors’ characteristics, such as their country, the institution where they work, and their degree or type of experience.

### 3.2.2. Rhetorical techniques

Typical argumentation techniques are used intensively to convince the patient about the diagnosis or to persuade him/her to perform the therapy. In Figure 3, evidence supports

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<th>TABLE 2</th>
<th>Information Items in the Doctors’ Explanations</th>
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<td>future developments of treatment</td>
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the diagnosis (1A-1B) or the statement of the severity of the disease (3A-3BC); a concession supports the need to treat the disease in spite of its mildness (3AC-3DE). To ensure that the patient really understands the intended therapy, a restatement is used (4A-4B) and, in other cases, an elaborate set-member is used to define the drug. The nurse explanation (Figure 4) is more informative and less argumentative: it does not use evidence in DS1. The message states briefly the immediate actions, and also what has to be done if a new situation occurs; the description of this situation is linked to the action by a relation of condition. Finally, a justification relation is used to exclude undesirable consequents of prescribed drugs (necessary to persuade the indirect user to administer or to take the drug). However, this is done in different ways for the two classes of indirect user. The patient is informed about controls that will be made (e.g., checking that the patient does not have an ulcer before prescribing medication known to upset the stomach). These controls are the nucleus of the relation, whose satellite is the description of possible undesirable consequents (5AB-5CD in Figure 3). In the nurse explanation, the description of undesirable consequents is omitted. The doctor simply assumes that the appropriate controls have been made, and mentions them (3AB, Figure 4) to justify the recommended therapy (utterance 2).
3.3. Conclusions

The structure of a "generic" explanation that covers alternative ways of illustrating a drug prescription can be represented by a hierarchical structure of communicative actions. To each action are attached two ratings of importance: an importance to the direct user (RID) and an importance to the indirect user (RII). RIDs vary

FIGURE 3. Rhetorical structure of the text shown in Figure 1.
according to the direct user and to the category of indirect user to whom the message is addressed (nurse or patient). Indirect users' knowledge of concepts is also relevant to decide what to introduce in the explanation. The three parameters are correlated but not totally interdependent. Indirect users might ignore a concept, and have no interest in being informed about it. Direct users might want to avoid talking about a subject even if they assume that the indirect user does not know it, and so on. Finally, the content of the explanation is also affected by the clinical context. Detailed instructions about drug administration are usually irrelevant in the case of a simple therapy such as aspirin.

If the information content of explanations is a function of the structure of action goals, their coherence is ensured by the structure of rhetorical relations: in text generation, rhetorical relations allow the introduction of linguistic markers that make clearer the relative role of two or more spans. Linguistic markers are especially important when these roles are not evident, and when understanding these roles is crucial to understanding the message (Ingham, 1993). Hence, they are necessary for some groups of communicative actions, and for some indirect users. In addition, attaching different rhetorical relations to the same action allows the style of interaction to be adapted. The two different uses of a justification to exclude undesirable consequents of prescribed drugs, in Figures 3 and 4, is an example of this adaptation. The same objective can be achieved, as well, by using a concession whose satellite is the description of undesirable consequents and whose nucleus is the description of the therapy. In this case, one can add to the text the declaration that negative results of controls prove that undesirable consequents do not apply in the specific case; this text span can be linked to the description of the therapy as in the example of the nurse's message.

4. THE EXPLANATION MODULE

4.1. Functions

As we anticipated in the Introduction, our explanation module can be seen as a scrivener, which helps the prescriber in generating the explanation. Thus, after having completed the prescription, the doctor asks OPADE to generate the explanation, and specifies the indirect user to whom it has to be addressed. OPADE knows what the doctor would like to see in the explanation (or presumes to know it). However, it is not totally submissive to the doctor's wishes: it also tries to respect the indirect user's wishes as far as possible. It then generates an explanation that mediates between the two users' views: a message that is convincing to the indirect user (in order to increase probability of compliance) and that is, at the same time, acceptable to the direct user who has to deliver it.

The generated message is displayed: the direct user can accept it, or he/she can ask to modify specific parts of it (to delete a text span, to add more detail, or to modify its style). The request is seen by the generator as a plan failure, and a diagnosis of the reasons for failure is made. The failure can be due to an error in the system's image of the direct user; for example, the doctor was presumed to consider an information item important but does not want it included in the explanation. Or, it can be due to differences between direct and indirect users' views; for example, the doctor would not have mentioned the side effects of a drug when talking to the nurse, but the system introduced them in explanations because nurses want to know them. Finally, it can be due to an error in the explanation strategy; for example, the doctor may consider it wrong to instruct patients with a low educational level about administration of simple drugs by just mentioning the dosage. Taking corrective action requires different measures. In the first case, OPADE will cor-
rect its image of the direct user, and will revise the message accordingly. In the second one, it will try to justify the reasons why the discussed text span was introduced in the explanation, by mentioning the communicative action that it was aimed at achieving and the presumed information needs and knowledge of the indirect user. If needed, it will then negotiate, with the direct user, a new version of the message. In the third case, OPADE will recognize its error. If the error is due to absence of information in the Domain KB, the doctor will be required to introduce the missing part in the text; otherwise, the strategy will be revised.

4.2. Architecture

Figure 5 shows the main components of OPADE's explanation module. The text organization is established by a hierarchical expansion planner, according to strategies represented in a library of plan operators. The surface generation of the text is made by activating a list of ATNs corresponding to the generated plan and by filling up their parameters with values from the Domain KB (Miller & Rennels, 1988). Planning and surface generation activities are guided by the description of direct and indirect users' characteristics, represented in two separate models. In case of plan failure, an ad hoc module is charged to diagnose and repair the failure. The repair procedure requires initiating a dialogue between the system and the direct user, to negotiate changes to be made. The dialogue may end up with a new planning—generation cycle and, possibly, with a revision of the direct user model and of the planning strategy. In this way, OPADE progressively learns to generate messages suited to the preferences of people with whom it interacts.

4.3. Planning Operators

Our planning operators take hints from those employed in EES (Moore and Paris, 1992) and in TEXPLAN (Maybury, 1992, 1993). They have the following slots:

- **Constraints** encode conditions on the Domain KB.
- **Intentional constraints** encode conditions on the system beliefs about the mental state of the indirect user (IU). Both categories of constraints have to be true for the operator to be applied, and cannot be affected by the planning agent.
- **Preconditions** and **Effect** indicate system beliefs about the mental state of IU before and after the communicative action formalized by the operator. If a precondition is not verified, another operator can be invoked to make it true. Mental states are represented by assertions concerning the IU's knowledge of specific subjects (KNOW-ABOUT (IU, subject)), or competence or intention to perform an action (KNOW-HOW (IU, action)), (WANT-TO-DO (IU, action)). The second argument of these predicates may correspond to a constant, a variable or a functional expression. During the planning, values of variables are instantiated by using pattern-matching with data about the specific prescription that has to be explained.

3 In all formulae mentioned in this paper, binary relation constants denoting direct or indirect users' characteristics are represented with capitals. The same notation is used for constants. Variables appear in italics. Relational or functional predicates on the domain begin with capital letters, as well as predicates denoting communicative actions, rhetorical relations, or speech acts.
• **Header** and **Decomposition** indicate, respectively, the communicative action formalized by the operator and the way that it can be expanded into one or more subgoals. A subgoal can be "optional." This means that, although it is useful from the communicative point of view, its elimination does not entail loosing coherence in the text. As the main purpose of the explanation is to encourage the IU to perform the drug therapy and, subordinately, to support related conclusions, typical argumentation strategies of Request—Enable—Persuade and of Describe—Persuade are adopted (Maybury, 1992, 1993; Moore & Paris, 1992). The Decomposition slot may contain a primitive action of the communication process, that is an illocutionary speech act such as Assert (proposition) or Direct (action). An illocutionary act can be transformed into different surface speech acts. For example, a Direct speech act can be realized by a Suggest, an Ask, a Command and so on. Each of them is appropriate for some direct user and in some circumstance. We found, in our studies, that English doctors tend to employ an Ask when addressing instructions to a nurse, whereas Italian doctors tend to use a Command in the same context. This possibility of choice is represented, in our plan library, by several operators having the same header (an illocutionary speech act) and different decompositions (surface speech acts).

• **Rhetorical Relation** indicates the name of the relationship between elements in the Decomposition, which are marked as Nucleus (N) or Satellite (S).

### 4.4. Double Modelling

#### 4.4.1. Indirect user model

Assertions about the presumed mental state of the direct user are encapsulated in a stereotype. In order to reduce information to be stored in this model, elements of the Thesaurus are categorized according to their complexity. Indirect users' knowledge about these categories of entities and their attributes, and intention to perform related actions are stored in the stereotype. In addition to knowledge and intentions, the Indirect User Model includes interest about subjects that are represented by WANT-TO-KNOW predicates and correspond to the ratings of importance (RIs) defined in 3.1. RIs are coded in three classes: H = high, M = medium, and L = low. Figure 6 shows examples of assertions in an IU model.

#### 4.4.2. Direct user model

OPADE has a model of the direct user that it uses to adapt other aspects of interaction, like preferences about physical features of the interface, rights of access to specific functions and so on. This model is activated by addressing a few "trigger" questions to the user at the beginning of the interaction. We added a set of assertions to this model to indicate the propensity to talk about specific subjects, when the message is addressed to each category of indirect user. These characteristics are represented by WANT-TO-SAY predicates, and correspond to the ratings of importance (RIs) defined in 3.2. The following assertion in the direct user's (DU's) model of Figure 6:

WANT-TO-SAY (DU, Expected Effects (DrugCategory1), NURSE, L) states that this direct user does not give much importance to mentioning expected effects of drugs in the category 1 when giving explanations to nurses. Finally, preferences about styles are represented as assertions on the PREFER predicate. For example, PREFER (DU, direct, NURSE, COMMAND) states that this direct user prefers using a "command" speech act when talking to a nurse.

### 4.5. Planning as a Mediation Between Different Viewpoints

The planning process is initiated by posting a top communicative goal (Explain the prescription of a medication for a given patient) that corresponds to the header of the top operator. Goal refinement is made by matching header-decomposition fields. As we mentioned in the previous paragraph, we make the hypothesis that the factors that influence adaptation are: (a) knowledge, intentions and interests of IUs and (b) propensity and preferences of DUs. Some of these features (knowledge and intentions of the IU) are mentioned in the operator's preconditions and intentional constraints, and thus guide selection of the operator to be applied. If a precondition is not verified, another operator is activated to achieve this effect, by pattern matching on precondition—effect fields. If no such operator exists or a domain or intentional constraint is not verified, the operator fails. The operator also fails when all its optional subgoals fail.

The other features, IU's interests and DU's propensity and preferences, determine selection of the "best way" to inform or to convince the IU about something, and, therefore, of the discourse strategy to apply. If direct and indirect users' views are different, this strategy is the result of a mediation, which attributes different weights to these different interests, preferences, propensities, according to general considerations about the explanation purpose and the context where explanation is provided. Some examples of strategy are as follows:

**S1.** "An indirect user's moderate interest for a subject has to be satisfied even if the direct user is not particularly inclined to talk about the subject, unless this makes the explanation too long;"

**S2.** "If the direct user tends to prefer command-type direct speech acts and the indirect user has not much health care experience, then this speech act has to be used."


We represent these strategies separately from the plan operators’ knowledge, as metaplanning rules. Expand rules decide whether or not to expand a node corresponding to an “optional” subgoal in the planning hierarchy. Their right side has the form: WANT-TO-SAY (System, Subject). Select rules decide which operator to select in case of conflicts originated from different operators having the same header and effect. Their right side has the form: SELECT the planning operator having a specified Decomposition value.

The left side of metaplanning rules is a logical combination of conditions on the IU’s interests and the DU’s preferences and propensities. In addition, conditions on the level of complexity of the plan, on the domain knowledge and on general IU’s characteristics can be added. The separate representation of criteria into metarules gives the greatest flexibility in graduating the mediation between indirect and direct users’ views according to the specific situation. As usual, explicit representation of this control knowledge has a lot of advantages, such as the possibility of using it to justify a message, of revising the criteria after evaluation, and so on. It does, however, have the disadvantage of slowing down the planner performance, as the planner has to look at the two user models before deciding to apply a candidate operator.

Figure 6 gives an example of adaptation of the information content, by an Expand rule that encodes the strategy S1. The optional subgoal: Describe(DesirableConsequents of the planning operator: Describe(DesirableConsequents(Administer(drug, patient))) is expanded only if the Expand Rule is fired, that is if the plan is not too complex. An example of Select rule that encodes the strategy S2: If PREFER (DU, direct, IU, command) and Experience (IU, L) then SELECT (S, command).

The result of the planning process is a tree, which represents the hierarchical structure of communicative
actions and rhetorical relations. Terminal elements of this structure are surface speech acts. The surface generator selects an appropriate ATN for each of these terminal elements of the plan and fills up their parameters with values from the Domain KB.

4.6. An Example

Let us consider the case of an explanation addressed to the 63-year-old angina patient described in the scenario of 3.2. We will describe how the segment of the discourse aimed at persuading the patient to take the second drug in the prescription is generated. We cannot describe all planning operators relating to this part of the text generation. However, we will refer in particular to those shown in Figure 6, plus the ones shown in Figure 7.

The text plan is shown in Figure 8. In this figure, note that some subgoals are not expanded (the corresponding text is an *). This is due to several reasons. In some cases, Expand rules were responsible: interest and propensity for Contraindications were, respectively, low and medium for the patient and the doctor; they were medium and low for Interactions. So, in both cases, metarules established that they should not be mentioned in explanations because the generated text would have been too long. The “Side effects” subgoal was expanded because interest of the patient for this item was high. Other subgoals were not expanded because relevant information was not available in the Domain KB, for this drug: how the drug works, risks of not taking it, severity of side effects. A rhetorical relation of concession was used to explain side effects of this drug by mentioning their expected evolution, because Measures to take against these Side effects were not known. Finally, the Therapeutic class of the drug was mentioned in the text because the precondition KNOW-ABOUT (IU, drug) was not true in the patient model.

5. COMPARISON WITH RELATED WORK

Assigning to the system the role of a mediator between speaker and hearer entails some differences between OPADE’s explanation module and previous text planning systems. We will examine these differences by making special reference to three systems: Hovy’s PAULINE, Moore and Paris’s EES, and Maybury’s TEXPLAN.

5.1. Hearer Representation

These three systems tailor information content to the hearer knowledge. The hearer goals are aimed mainly at focusing the discourse on subjects of interest to the hearer, through appropriate variable binding. The hearer interests are not considered in these systems: it is left to the speaker to decide what it is important to say, and the hearer model only contributes by not dwelling on subjects that are already known. The strategy used to generate the explanation is the speaker’s strategy. Moore and Paris plan to tailor the plan selection heuristics to the hearer preferences in a future version of EES. However, they plan to adapt general characteristics of the explanation (such as “be brief/verbose”). We think that the information content of each text span in the explanation has to be adapted to the related interests of the hearer. As a consequence of this choice, our hearer model is more complex.
propensity to say. There are, instead, several potential speakers in OPADE. Furthermore, OPADE has to do its best to imagine the explanation strategy that each of them might prefer; this strategy is a function of the hearer to whom the message is addressed. Thus, we have to represent the speaker characteristics in a model. The importance attached to each subject and the propensity to talk about it are not coincident. For example, some doctors prefer not to disclose the diagnosis of a serious disease to patients even though they know it is relevant, because they think that it might entail negative consequences for the psychological health status of the patient.

5.3. Planning Direction

We were tempted by the idea of generating our explanations according to a "bottom-up" approach. We had a list of information items available in our KB, and a rating of importance attributed to each of them by each category of direct and indirect user. We might then select the items to be included in the explanation as a compromise between the two rating scales, and generate a coherent text by using appropriate rhetorical techniques, as in Hovy (1988). With this approach, adaptation of the text and resolution of conflicts between direct and indirect users' views would have been made at the level of information items to be included in the text and rhetorical relations between them, rather than in terms of communicative actions. However, translating results of our two experimental studies in terms of adaptation of action goals was much more natural and rational to us. Moreover, representation of effects of each communicative action on the IU's mental state gave us the possibility of defending and, if necessary,
repeating failed plans. For these reasons, we preferred a prescriptive, "top-down" approach.

5.4. Plan Operators

We see the following main differences between EES's and TEXPLAN's operator structures:

5.4.1. Use of rhetorical structure theory. This ensures coherence of the text. EES plans start from a (high level) discourse goal, and expand it in terms of rhetorical relations, until coming to primitive linguistic acts. As the backward chaining of operators is made on the effect-nucleus or the effect-satellite couples, the three slots may contain a high level discourse goal or the name of a rhetorical relation. Nucleus and satellite may also contain a primitive linguistic act. TEXPLAN eliminates rhetorical relations from the operators, to include "rhetorical predicates" as classes of primitive linguistic acts with different semantic content. Looking at examples of propositions presented in Maybury's articles, one notices that they correspond, in most of the cases, to text spans including both nucleus and satellite of a rhetorical relation. For example:

purpose: "He talked in order to avoid torture."
motivation: "Substance abuse motivated him to steal."
evidence: "Red splotches suggest measles."

In other cases, the proposition contains only the nucleus or the satellite. For example, the inference/conclusion proposition describes the nucleus of a background rhetorical relation.

There are, in our opinion, several consequences of Maybury's choice: (a) the "grain size" of his planner is coarse; his rhetorical propositions are full phrases, whereas Moore and Paris's primitive acts may be fragments of a phrase or even single words; (b) rhetorical relations between parts of the text are introduced explicitly, by linguistic markers, only in the peripheral part of the plan and not at the higher levels of the hierarchy; and (c) when the same nucleus supports several satellites, to which it is linked by different rhetorical relations as in: "I prescribed Lasix, a hypertensive (classification) in order to reduce your blood pressure (purpose)," the nucleus has to be repeated several times.

5.4.2. Types of slots. Knowledge organization in TEXPLAN's operators is more rational than in EES's: (a) the conditions of application relating to the baseline domain are separated from those referring to the mental state of the hearer, in constraints and preconditions; (b) in addition, the operator's results concerning the communicative acts and the mental state of the hearer are represented separately in header and effects. This organization improves readability of the operators and makes the planning process more efficient. Our operators are a compromise between the two proposals, as they represent both the pattern of communicative actions and the rhetorical structure of the text. The text plan, thus, indicates the purpose of each part of the explanation and how different parts are related to each other. Rhetorical relationships between large or smaller spans of texts can be evidenced by means of appropriate linguistic markers. At the same time, the reason why each intentional goal and each rhetorical relation was selected, according to criteria of mediation between the two users' views, can be justified when needed. One might argue that propositions in the effect field should be unique, and that having multiple propositions does not allow separating intended effects from side effects, nor representing the relationships between intentions that are needed to recover from plan failures. This is true in dialogue systems. But, OPADE will not engage in conversations with indirect users, and, therefore, only has to be able to repair the types of failure mentioned in 4.1. Knowledge organization in our plan operators serves this purpose. When an explanation segment is questioned, the operator that was responsible for generating it is located, as well as the metarules that establish expansion of subgoals or selection among alternative operators. Thus, the system has the information it needs to diagnose the reasons of failure, and will ask the DU for further clarifications aimed at identifying the specific cause of the failure itself.

6. CONCLUSIONS

Although our research is motivated by a well-defined application purpose, we believe that our method can be applied in other situations where the system cooperates with the user to generate a written message whose ultimate addressee is someone who does not interact with the system itself. In this case, explanation generation implies achieving a consensus in a two-agent environment, and, therefore, requires explicit and complete information about the two agents' characteristics. In the solution we propose, the system behaves as a mediator between the two agents' views, and negotiates with the interacting agent the best "compromise" solution. The weight given to each agent's view in the negotiation can be graduated by changing metalevel strategies. This allows adaptation of the strategies to the roles played by the two agents in the domain context to which the explanation refers, and to their relationship.

In this article, we have only described how we generate the first explanation. We still have to define in detail the way that we plan to diagnose and repair plan failures, by revising the DU model at the same time. Even before engaging in evaluation of generated texts, we know that explanations produced from our
first prototype are much more rudimentary than those that a physician would provide, and that they would not easily pass the examination of a linguist, as far as their style is concerned. As we do not represent the focus of attention of the discourse, its coherence will probably be insufficient. However, the main purpose of the evaluation will be to assess whether IU are satisfied with explanations that OPADE is able to provide. We also have on our side the fact that the texts we will produce have no "natural" alternative, at present. In most cases, IU do not receive any explanation on the drug prescription from the physician. Often their only information source is the company's leaflet attached to the drug packet. Therefore, we hope that they will appreciate even the suboptimal product of our system, provided that it responds to their information needs. Of course, this will be matter for future evaluation.

REFERENCES


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