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Modeling Information-Seeking Dialogues: The *Co*nversational *R*oles (COR) Model

Stefan Sitter and Adelheit Stein

Keywords

dialogue models, discourse theory, communicative acts, conversational roles, rhetorical structures, information seeking dialogues, information retrieval systems

Abstract

In this article we introduce a generic, application independent model of human-computer information-seeking dialogue, the "Conversational Roles" (COR) Model. We review the theoretical background that motivated our approach and discuss the COR model in detail, analyzing some typical example dialogues under various perspectives. In line with the theory of speech acts, the COR model categorizes dialogue acts on the basis of their illocutionary force (the purpose of the acts). These illocutionary acts and their functions during dialogue are described independently of the interaction modes employed (graphical, linguistic, or multimodal). COR is represented as a recursive state-transition-network (RTN) that determines all of the legitimate types and possible sequences of dialogue acts, focusing on the negotiation and temporary assignment, acceptance or refusal of conversational roles during interaction. We then argue for a combination of this illocutionary layer with other layers which represent semantic-thematic and rhetorical aspects of dialogue. We conclude with depicting the potential of such an integrated dialogue model for the design of both elaborate and easy-to-use interfaces to information retrieval systems and for research into communication disorders.

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Applications at GMD-IPSI

The dialogue model introduced here, called the "Conversational Roles" (COR) model, was developed at GMD-IPSI in 1990/1991. The current article reflects the state of our work during this time period, presenting a theoretically motivated approach to modeling information-seeking dialogue. In the following years, the model has been refined (but without major changes of the theoretical framework) and complemented by other modeling layers, as it was integrated into various information system prototypes developed at GMD-IPSI:

- MERIT (Multimedia Extensions of Retrieval Interaction Tools) was centered around a "case-based dialogue manager" using cases of successful retrieval sessions to guide the user step by step through a new session.
- CORINNA (COoperative Retrieval INterface based on Natural language Acts) provided a natural language interface and allowed for clarification dialogues in the query formulation phase.

As compared to the first prototypes, the two current systems employ a more sophisticated dialogue management (the first focussing on intelligent retrieval and dialogue techniques, and the second on the generation of spoken output in a given dialogue context).

- MIRACLE (MultImedia concept Retrieval bAsed on logiCaL query Expansion) combines a logics-based retrieval engine and a dialogue manager based on the COR model, exploiting the dialogue context to resolve ambiguous user requests and queries.
- SPEAK! (speech generation in information retrieval dialogues) combines a dialogue manager based on COR with an established text generation system (KOMET-PENMAN) to generate properly intonated meta-comments about the retrieval dialogue itself.

(§1)

1 Introduction

A variety of approaches to discourse modeling have been developed in computational linguistics and Artificial Intelligence (AI). Their scope differs depending on their embedding in *research areas*, such as text analysis/generation, knowledge-based dialogue planning, or intelligent user interface design, as well as with respect to the *discourse genre* and *application context* in question.

(§2) The dialogue model presented in this article, the "*Co*nversational *R*oles" (COR) model, has been developed at GMD-IPSI within the "Cognitive User Interfaces" research division [cf. Hoppe et al. 1989]. A first prototype dialogue manager was developed which was tailored to access an experimental hypermedia system in the domain of conference information, called SIC! [cf. Stein, Thiel and Tißen, 1991]. To be re-usable for other applications, however, the core part of a dialogue manager which controls the user-system interaction must be application and domain independent. Therefore, a more elaborate dialogue manager than the one employed in SIC! should be based on a multi-layered dialogue model, the domain-dependent layers of which must be exchangeable.

(§3) The most abstract domain-independent layer is concerned with the pragmatics of a dialogue, or, in terms of the theory of speech acts, with its "illocutionary" layer. Modeling these illocutionary aspects, COR is capable of structuring the dialogue and representing the cyclic process of negotiation (e.g., question, checkback, proposal, counter proposal, rejection, withdrawal, answer, and evaluation of the answer). As such it simulates natural conversational tactics of human-human dialogue and hence can serve as a basis for the design of user interfaces that are easy to use and offer interaction options users are accustomed to. Proposing a multi-layered dialogue model, we draw on distinctions between different, but interrelated, levels of interaction knowledge [cf. King, 1989; Viehweger, 1989]. In the remainder of this article, we focus on the illocutionary level.

(§4) In our approach, user and system are treated as dialogue partners or agents that basically act *cooperatively*. Their dialogue contributions are interpreted as "speech acts" as put forward by the theory of speech acts [cf. Austin, 1962; Searle 1979; Searle and Vanderveken, 1985] or as "communicative actions" [Bunt, 1989] (a more general term which was coined to subsume nonlinguistic acts as well). Hence, we abstract from the modes of interaction (graphical, linguistic, multimodal) and claim that all of the dialogue contributions can be represented as tokens of the same abstract language. By performing a dialogue act, the speaker takes on a conversational *role*, assigning the addressee the complementary role (e.g., the global roles of information seeker and information provider). The concept of roles implies that there are identifiable *expectations* concerning the subsequent response [see also Halliday, 1985]. A model of the illocutionary level is to describe the types of dialogue acts that are possible in a given dialogue state and the associated role assignments and expectations.

(§5) The COR model is intended to hold for a dialogue type with the following characteristics:

- One dialogue participant needs information for some purpose, the other one is supposed to provide the relevant domain knowledge (information).
- Both participants negotiate the information problem and the related dialogue goals until they reach a *mutually agreed upon interpretation* of the problem and the information need can be fulfilled, or until the respective dialogue goal is retracted or refused.

(§6) This characterization restricts our *genre* to information-seeking dialogue, which is in contrast to other genres such as argumentative or narrative conversations, sales talks, etc. Our *application context* (access to information systems/information retrieval) is regarded as a special case of this dialogue type and did not influence the dialogue model decisively. The peculiarities of human-machine interaction can be ignored for the time being, but they certainly are important in the phase of the user interface design decisions.

(§7) Developing the COR model, we have drawn on the paradigm proposed by Winograd and Flores [1986] for the modeling of conversations. We will, therefore, discuss their "Conversation for Action" model in *Section 2* to some extent. Our modifications and extensions to their model are described in (*Section 4*) relates two influential discourse modeling approaches in computational linguistics to our model.

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(§8)

2 Winograd and Flores' "Conversation for Action" model

Winograd and Flores [1986] proposed a theoretical foundation for conversational analysis which combines a hermeneutic orientation with concepts of the philosophy of language.

They motivate their emphasis on the *pragmatic* aspects of interpersonal communication with their basic conception of language and cognition: The meaning of utterances is *construed* during the course of social communication; knowledge is not built up via transfer of information (representations of objects in a world), but it is the result of an *interpretation in context*. Thus, the *social dimension* is seen as essential for conversational analysis. Winograd and Flores regard the theory of speech acts (put forward by Austin [1962] and Searle [1979], and Habermas' theory of action [Habermas 1981]) to be initial steps towards an adequate theory of *meaning*, as these theories emphasize "language as action" (in contrast to the representational function of language). They state that in human-human conversation talking and listening are vehicles for the expression of behavioral expectations, building up a complex web of mutual commitments to determine the course of a conversation.

(§9) According to Winograd and Flores it is only on this level that the structure of conversations can be formally described. In their view, other levels are - on principle - inaccessible to formalization. We do not adhere to such a strong point of view, but prefer to regard their approach as an attempt to describe the pragmatic aspects of a conversation, while other aspects/levels should be taken into consideration as well.

(§10) As a prototypical example of *cooperative dialogue* Winograd and Flores present a so-called "Conversation for Action". They propose a model (here referred to as the "CfA model"), which describes possible sequences of dialogue acts and their interplay in progressive dialogue states. The dialogue genre is a two-party negotiation of one partner's intended - extra-dialogic - action and the other partner's evaluation of the result. The CfA model is the basis for the implementation of the "Coordinator", which is a mail system for the support of cooperative work in groups [cf. Winograd, 1988].

(§11) The CfA model is represented as the traversal of a state-transition network (*Figure 1*) with arcs representing speech acts and nodes representing dialogue states. The dialogue is initiated by partner A with a \`request', which may be followed by B's \`promise' to comply; B's proposal of a different action (\`counter'); B's \`reject' to comply; or A's own \`withdraw' of his previous request, etc.

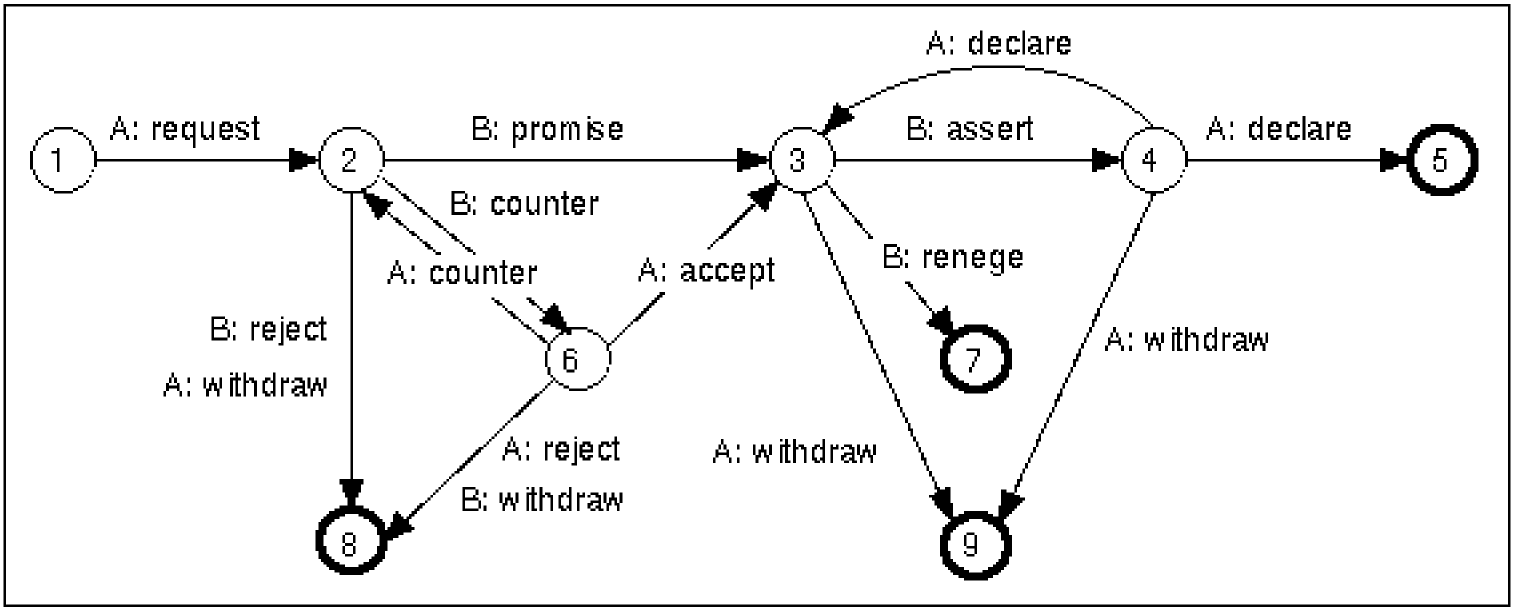


Figure 1: The basic "Conversation for Action" [Winograd and Flores, 1986, p. 65]

(§12) In this way, each of A's or B's actions gives rise to a new state, which is defined by its history and by its action space (the set of possible follow-up actions). The circles printed in boldface represent terminal states with no further action space. They differ from the non-terminal states only by the path that led to them. Even transitions with no corresponding utterance in the dialogue are allowed and can be interpreted as acts, i.e., the dialogue is continued *as if* the speech act had been uttered. For example, consent can often be inferred without an explicit `"I agree"` or `"I'm contented"`. Winograd and Flores call such acts "implicit dialogue acts". On the level of representation, these are `jumps', which are entered into the dialogue history as regular (empty) transitions.

(§13) If neither participant quits the dialogue prematurely, at some time the state of mutual acceptance of the requested extra-dialogic action is achieved (state <3>). This state can be followed by B's `assert' (transition <3-4>) to express that his commitment has been met, but it is also possible for B to `renege' or for A to `withdraw' his directive. In state <4>, only A can respond, either by an evaluation (one of the `declare' acts), or by a `withdraw' act.

(§14) Winograd and Flores had straightforward and simply structured conversations in mind. More complex paths or cycles are possible at two positions only: exchange of `counter' acts (transitions <2-6>), or A's non-acceptance of B's report of execution (transition <4-3>). Embedded clarification dialogues or meta-level dialogues are not addressed by the CfA model.

(§15)

3 Information-seeking dialogue: the "*Co*nversational *R*oles" (COR) model

3.1 Some requirements

In the genre of information-seeking dialogue we have to cope with special requirements an adequate dialogue model must account for. In order to point them out stepwise, some example dialogues will be presented using Winograd and Flores' CfA model for a preliminary analysis. For the sake of simplicity, natural everyday language is used to present the examples (although we assume that other interaction modes can be modeled by the same formalism).

(§16) A quite simple, straightforward dialogue is shown in *Example 1.a*. This dialogue is completely described by the CfA model: it takes the shortest possible path <1-2-3-4-5> through the network given in *Figure 1*. Obviously, A's query was answered in a satisfying way, permitting the dialogue to be quit. Slight variations would not cause any problems, e.g., a `counter' from B `"I can't tell you` *`where`*`, but I know` *`when`*`"`, plus an 'accept' from A (the path <1-2-6-3-4-5>).

Example 1.a:

A:	Where does the next IJCAI take place?	[request]	<1-2>
B:	Please wait, I'll look it up.	[promise]	<2-3>
	In Australia.	[assert]	<3-4>
A:	Thanks.	[declare]	<4-5>

(§17) However, A might be discontented and wish to reformulate his request (query). According to the CfA model, a new dialogue (see *Example 1.b*) would have to be initiated. This is not an adequate view because A's initiating question in *Example 1.b* does not make up a completely new request, but is rather a refinement of the original request in *Example 1.a*

Example 1.b:

A:	But where in Australia?	[request]	<1-2>
B:	I don't know.		
	But I can show you the Call for Participation.	[counter]	<2-6>
A:	OK.	[accept]	<6-3>
B:	Here it is.	[assert]	<3-4>
A:	No, I can't find it here.	[declare]	<4-5>

(§18) It is more appropriate to view our genre of dialogue as promoting a *cyclic* progression, with each dialogue cycle starting at state <1>. Therefore, we would rather permit A's `declare' act in *Example 1.a* to return to state <1>, considering also the connotation of the utterance `"Thanks"` which, in this context, actually implies that B is not completely satisfied with the answer.

(§19) Likewise, A's `declare' act in *Example 1.b* does not necessarily terminate the dialogue; it can give rise to further refinement of the query (see the continuation of the dialogue in *Example 1.c*).

Example 1.c:

A:	See if *you* can find it.	[request]	<1-2>
B:	OK, I'll have a look.	[promise]	<2-3>
	[... Pause ...]		
	Just a moment.	[?]	?*
	Wouldn't it be better		
	if I showed you the letter of invitation?	[counter]	<2-6>
A:	OK, thanks.	[accept]	<6-3>
B:	Here it is: August 1991 in Sydney.	[assert]	<3-4>
A:	Thanks!	[declare]	<4-5>

* no regular transition in the CfA network of Figure 1

(§20) *Example 1.c* also demonstrates a phenomenon which is common to information-seeking dialogues: Commitments once entered may be dissolved before they have been met. This is not possible in the CfA network in *Figure 1*: B can only retract his `promise' by terminating the dialogue, and in this case he would not be able to initiate a new dialogue with his offer to show the letter of invitation (as dialogues can only be initiated by requests for information).

(§21) Retraction of commitments and starting a new dialogue cycle should be allowed at any dialogue state. An information seeker often has only a vague idea about which or which kind of information is relevant for his purpose [cf. Belkin et al., 1987]. The same is true for the information provider. Therefore, *both* partners must be given the opportunity to clarify and/or correct their assumptions and intentions *during* the dialogue. The CfA model treats most of such processes as "breakdowns" which are to be "repaired" outside the modeled conversation. We prefer to model them - as far as possible - as parts of the dialogue itself.

(§22) Another, closely related, problem concerns the *allocation of initiative during* a dialogue. According to the CfA model, the information provider (B) is treated as a merely responding agent and thus has almost no opportunity to take the initiative. Although B can make a suggestion by a `counter', this can only happen as a response to A's initial `request'. We consider a mixed-initiative approach more appropriate: A dialogue cycle may start with an information offer uttered by B. (If B can anticipate, at least vaguely, A's dialogue goal, he can make an offer to A even at the very beginning.) Therefore, B's `counter' (transition <2-6> in *Figure 1*) should be decomposed into a *sequence* of a `reject request' plus an `offer'. This decomposition has a positive side effect: B is thus not *forced* to be constructive by making an alternative suggestion if he wants to decline A's request; B may confine himself to merely expressing a rejection and return the initiative back to A again. Likewise, A's 'counter' (transition <6-2> in *Figure 1*) is to be decomposed into a sequence of a `reject offer' plus a `request'.

(§23)

3.2 Basic COR dialogue schema

Figure 2 presents the COR transition network for `dialogue', which includes all of the necessary extensions of the CfA model we argued for above.

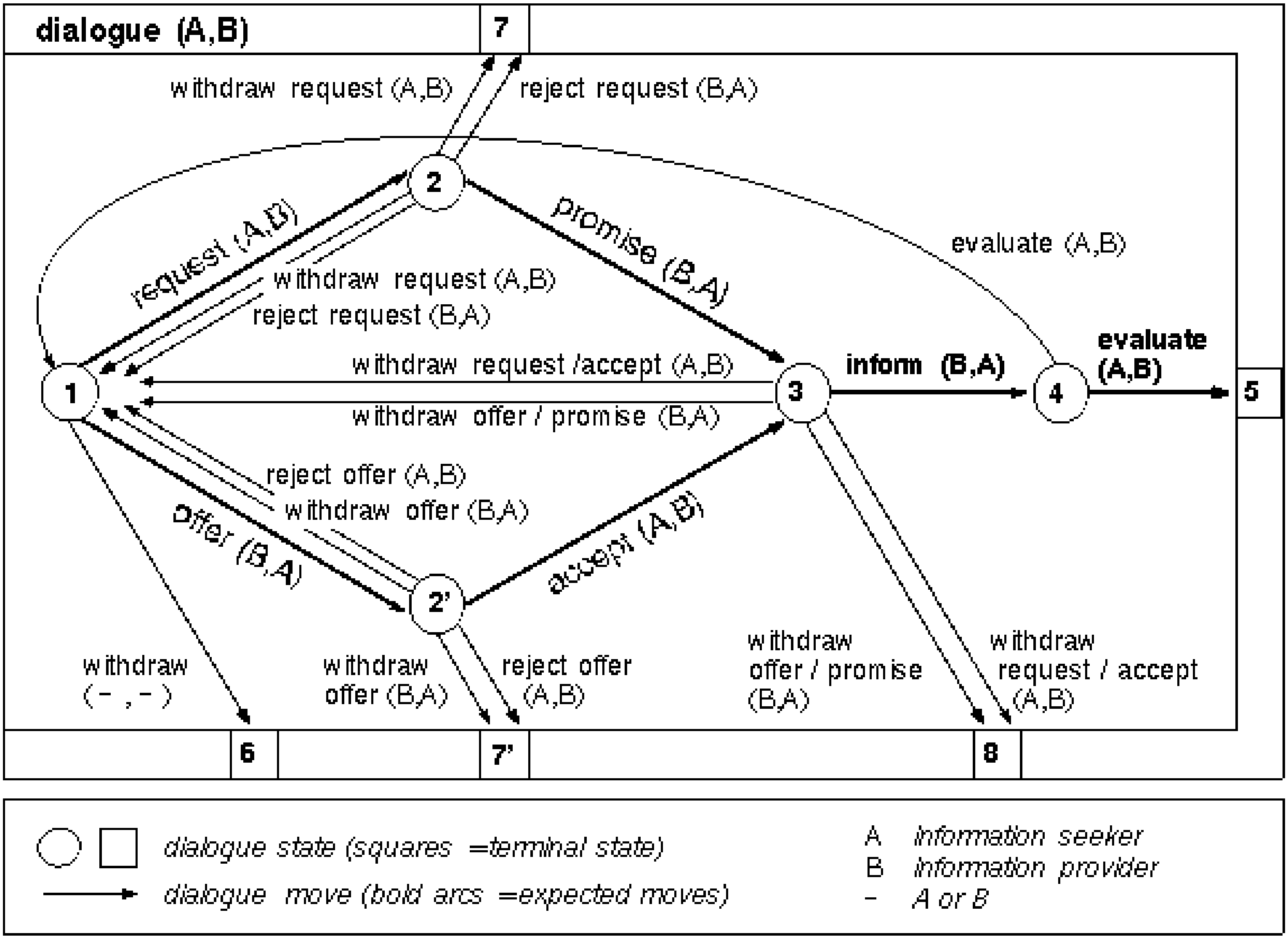


Figure 2: Basic COR schema for information-seeking dialogues

Notation of Figures 2 and 3

- All dialogue act labels of COR - the transitions - have two parameters `A' and `B'. They refer to the dialogue partners, A consistently referring to the information seeker who in most cases initiates the dialogue (but not necessarily all dialogue cycles) and hereby determines the implicit "hypertheme" [cf. Danes, 1970].
- The order of parameters indicates speaker/hearer roles, the first parameter referring to the speaker.
- The states represented by circles are dialogue states which must be followed by other transitions; the ones represented by squares are terminal states (the dialogue has been finished). State <1> is the initial state of the whole dialogue as well as of all dialogue cycles.

(§24) Now, traversal of this network can easily be illustrated by analyzing the dialogue example introduced above. *Example 2* (a contraction of *Example 1.a* to *1.c*) demonstrates the *returns* to state <1> permitting a refinement of the initial `request' and the *symmetry of initiative* by alternating sequences initiated by a `request' or an `offer'. Grey bars in the figure mark utterances of one cycle. The example should also make clear that the diction, the rhetorical means used, and the interaction modes may vary without modifying the illocutionary structure. For example, the actions `"OK"`, `"Fine"`, or nodding in face-to-face communication may be equivalent at a given state and express acceptance.

Example 2:

A:	Where does the next IJCAI take place?	[request]	<1-2>
B:	Please wait, I'll look it up.	[promise]	<2-3>
	In Australia.	[inform]	<3-4>
A:	Thanks.	[evaluate]	<4-1>
	But where in Australia?	[request]	<1-2>
B:	I don't know.	[reject request]	<2-1>
	But I can show you the Call for Participation.	[offer]	<1-2'>
A:	OK.	[accept]	<2'-3>
B:	Here it is.	[inform]	<3-4>
A:	No, I can't find it here.	[evaluate]	<4-1>
	See if *you* can find it.	[request]	<1-2>
B:	OK, I'll have a look.	[promise]	<2-3>
	[... Pause ...]		
	Just a moment.	[withdraw promise]	<3-1>
	Wouldn't it be better	[offer]	<1-2'>
	if I showed you the letter of invitation?		
A:	OK, thanks.	[accept]	<2'-3>
B:	Here it is: In August 1991 in Sydney.	[inform]	<3-4>
A:	Thanks!	[evaluate]	<4-5>

Grey bars mark cycles of the dialogue (restart after return to state <1>)

(§25)

3.2.1 Types of dialogue acts

The dialogue act types, which have been illustrated by examples, will now be described in accordance with Searle's terminology and "taxonomy of illocutionary acts" [Searle, 1979; Searle and Vanderveken, 1985]. In order to avoid ambiguity, we have adopted Searle's terms as far as convenient. "Illocutionary force", "sincerity conditions/ psychological state", and "propositional content" are the three most important dimensions of classification. Other dimensions proposed by Searle, e.g., "status of the dialogue partners", are neglected here.

(§26) In the COR model `request', `offer', and `inform' can exactly be mapped onto Searle's basic categories directives, commissives, and assertives (we do not consider Searle's declarations and expressives) (see *Table 1*). `Promise' and `accept' are commissives and directives respectively. In contrast to examples usually given, they do not introduce new actions to be negotiated, as they may adopt the previously defined conditions of action.

(§27) The various `withdraw', `reject', and `evaluate' acts also refer to the propositional content of previous dialogue contributions, but they discard pending commitments. Therefore, their common feature is that they terminate a dialogue cycle, either *quitting* the dialogue or *leaping* to state <1>.

Table 1: Categorization of dialogue acts in the COR model

dialogue act	**illocutionary force/point**	**sincerity conditions *(schema of `p' in brackets)***	**relation of the dialogue act to the dialogue history**
request	directive	wish [H does A]	A is formulated *here*
offer	commissive	intention [S does A]	A is formulated *here*
inform	assertive	belief [p]	p is relevant in the dialogue context
promise	commissive	intention [S does A]	A of preceding request
accept	directive	wish [H does A]	A of preceding offer
evaluate <4-5>	assertive	belief [p is sufficient]	p of preceding inform
evaluate <4-1>	assertive	belief [p is insufficient]	p of preceding inform
withdraw request	directive	wish [not (H does A)]	(H does A) of preceding request
reject offer	directive	wish [(not (H does A)]	(H does A) of preceding offer
withdraw offer	commissive	intention [not (S does A)]	(S does A) of preceding offer
reject request	commissive	intention [not (S does A)]	(S does A) of preceding request

S=Speaker, H=Hearer, A=Action, p=propositional content; *conditions referring to the dialogue act* are expressed in column 3 by the schema to which p must conform, e.g., `[H does A]'; c*onditions referring to the dialogue course* are expressed in column 4.
Both are "content conditions" according to Searle.

(§28)

3.2.2 Role expectations

The categorization of dialogue acts in *Table 1* demonstrates that the *temporal* relations between dialogue acts are very important and should be elaborated. A conceptualization in terms of *role assignment* seems to be the most appropriate one, as they directly relate social and temporal aspects. At this point, we do not refer to *global roles* (information seeker vs. information provider), but to *micro-roles* associated with each single dialogue act: The speaker takes over a role (e.g., of the asker/answerer, the offerer, or the critic) and thereby assigns the hearer/addressee the complementary role. Roles are defined by behavioral expectations that the addressee's *subsequent* response must take into account. Halliday [1984], while considering a different dialogue genre with different global roles, also uses the concept of role assignment. His conceptualization contains, among others, "initiating" and "responding" roles.

(§29) In an *ideal case*, both participants are able to fulfill each other's expectations completely and immediately. This implies that either partner A is fully able to express his information needs in his `request', or that B already knows A's needs and makes an appropriate `offer'. B is able and willing both to understand and to fulfill A's needs immediately. B then presents exactly the needed information, and A is fully contented with this presentation. A network describing this ideal course of action is presented in *Figure 3* - of all acts in *Figure 2* above, it contains only those forming the *expected course of action*.

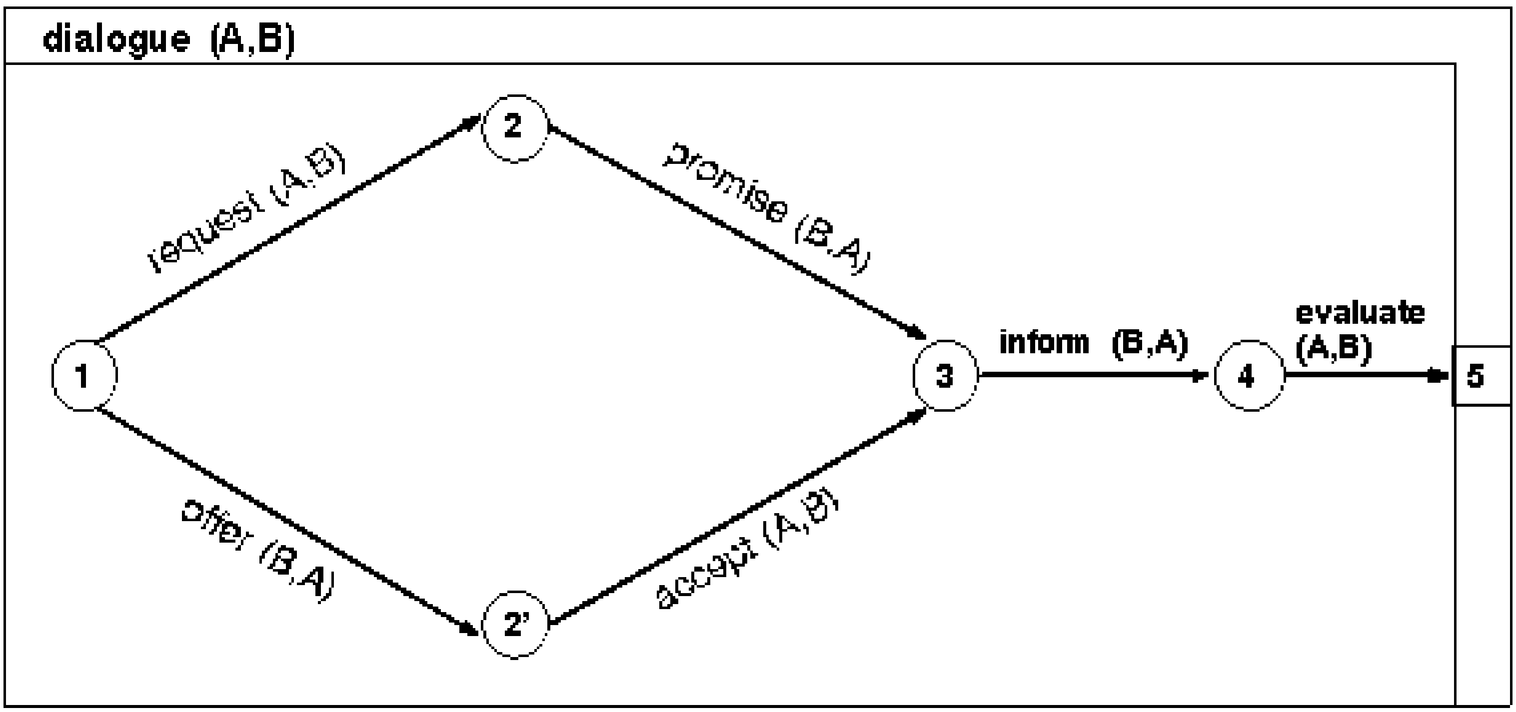


Figure 3: Partition of the basic dialogue schema containing the expected dialogue course

(§30) The basic dialogue schema (*Figure 2*) contains the additional transitions `withdraw ...', `reject ...', and `evaluate' (transition <4-1>). They either go back to the initial state <1> (permitting cycles or retrials) or quit the dialogue prematurely (terminal states, discarding unfulfilled role expectations). These are called *alternative dialogue acts*. There are several reasons why alternative dialogue acts happen: A may not be fully able to express his or her needs, those needs may change, or B may misunderstand A's needs or be unable to fulfill them. Paradoxically, only *few* dialogue acts are *expected* ones: "Expectation" in this sense has nothing to do with a *statistical* expectation. For example, when A poses a difficult query, he thereby expresses the expectation that B is willing and principally able to give an answer at some time, but A may even anticipate B's failure in *this particular* dialogue cycle. Alternative acts have to be presented and interpreted in the light of the expected course.

(§31)

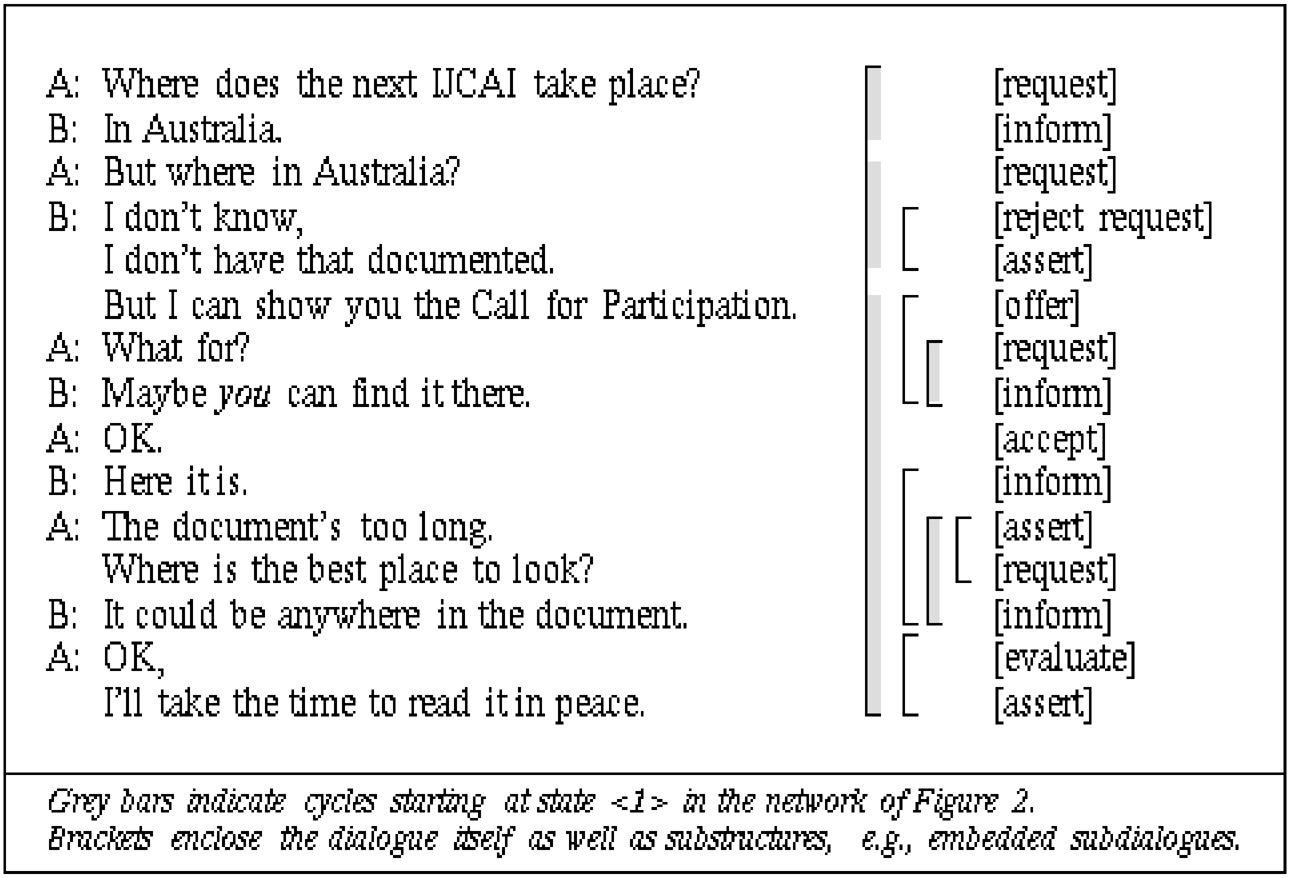
3.3 Further requirements

Upon a close look, the dialogue example used above still seems to be artificial. Often dialogues contain some or all of the following phenomena:

- Dialogue contributions may be omitted for the sake of efficiency if the corresponding psychological state (e.g., the intention to meet a specified requirement) can be reconstructed from extradialogic sources; *implicit dialogue contributions* can occur. *Example 3* - in contrast to *Example 2* - contains `*jumps*', e.g., B's promise `"I'll have a look"` is missing.
- Dialogue contributions may be backed by additional *context information* providing background for their interpretation. In *Example 3,* B's rejection `"I don't know"` is accompanied by the assertion `"I don't have that documented"` (`assert').
- The process of negotiating an action does not occur via flat rejection of a `request' or an `offer' (transitions <2-1> or <2'-1> in *Figure 2*) plus a new beginning from state <1>. There are mechanisms that can *postpone* a decision on whether or not to meet role expectations. An example is the embedded subdialogue in *Example 3* initiated by the `request' `"What for?"`. Only after the answer `"Maybe you can find it there"` has been obtained is the previous `offer' "`But I can show you the Call for Participation`" accepted. Postponement may also serve other purposes, e.g., to find out the motivation for the partner's decisions.
- *Indirect speech acts* [Searle, 1975] often increase the efficiency of communication. Instead of an explicit `request' (`"Which is the next big AI conference?"`), an `assert' may be uttered (`"I want to submit a paper"`), and the addressee might be able to infer the indirect `request' from the context.

(§32)

Example 3:



A:	Where does the next IJCAI take place?	[request]
B:	In Australia.	[inform]
A:	But where in Australia?	[request]
B:	I don't know,	[reject request]
	I don't have that documented.	[assert]
	But I can show you the Call for Participation.	[offer]
A:	What for?	[request]
B:	Maybe *you* can find it there.	[inform]
A:	OK.	[accept]
B:	Here it is.	[inform]
A:	The document's too long.	[assert]
	Where is the best place to look?	[request]
B:	It could be anywhere in the document.	[inform]
A:	OK,	[evaluate]
	I'll take the time to read it in peace.	[assert]

Grey bars indicate cycles starting at state <1> in the network of Figure 2.
Brackets enclose the dialogue itself as well as substructures, e.g., embedded subdialogues.

The basic network given in *Figure 2* has to be provided with additional features to cover these phenomena adequately. After these features have been introduced, *Example 3* will be analyzed more thoroughly.

(§32)

3.4 Extended COR schema

The transitions in the basic dialogue schema *(Figure 2)* have so far been interpreted as representations of atomic dialogue *acts*. In the light of *Example 3*, this has to be revised. The further requirements can be met by interpreting these transitions as *complex* dialogue contributions, which will be called *moves*. Each dialogue transition in the main network has an internal structure, such that a transition is done by traversal of another network (a move schema). Formally speaking, the dialogue network is no longer a simple state-transition network, but becomes a recursive transition network (RTN) [cf., for example, Winograd, 1983].

(§33) The distinction between dialogue *act* vs. dialogue *move* is analogous to the one made by Fawcett et al. [1988], who designate atomic speech acts as "acts" and their assembly into substructures as "moves" of "exchanges" (=dialogues). Atomic acts and their superordinate complex dialogue moves have the same functions for the dialogue development. For this reason, the categorization of dialogue acts in *Section 3.2.1* is equally valid for complex moves. The distinction between the two terms is, however, only necessary when internal structure is discussed.

(§34)

3.4.1 Structural view

To meet the new requirements summarized above, all transitions in the basic dialogue schema are now interpreted as complex move schemata/networks. Move networks are composed of three types of transitions:

- atomic dialogue acts,
- `jumps', and
- (recursively) other moves or complete (sub)dialogues.

(§35) We distinguish three types of move networks (represented by *Figures 4 - 6*). The first and the second are "degenerate" cases which are sufficient for a few types of moves. The last is the most general and complex one, the intention of which is to cover most move cases encountered in real information-seeking dialogues.

(§36) The simplest schema type is appropriate for the dialogue moves `promise' and `accept' *(Figure 4)*. In order to perform the <2-3> transition in *Figure 2*, actually the `promise' schema has to be inserted: <2> is mapped onto state <a>, and <3> is mapped onto state <c>. The `promise' schema has two options:

- an explicit atomic `promise' (with only one possible content, that is, to to commit oneself to look up and provide the requested information);
- a `jump', such that the `promise' transition can be skipped completely. Thus, a `request' may be followed directly by an `inform' - a phenomenon that often occurs in dialogues (e.g., `"Who organized the workshop?"` (`request') `"Professor Feiner, Columbia University."` (`inform')).

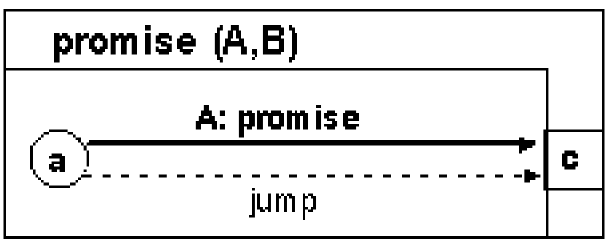


Figure 4: Schema for `promise' moves (analogous `accept')

Notation of Figures 4 - 6.

- the suffix notation already introduced, e.g., `promise (A,B)' or `dialogue (B,A)', is reserved for complexly structured moves and dialogues;
- a prefix notation, close to Winograd and Flores' notation *(Figure 1)*, is used for atomic acts, e.g., `A: promise', with A referring to the speaker (atomic acts are represented by bold arcs);
- the items in brackets, e.g., [supply context information], indicate the function of the move or subdialogue for the move in which they occur;
- `jump' transitions (dotted arcs) are made without an explicit utterance.

(§37) The `promise' structure is so simple because the negotiation of conditions for promising has already taken place in the previous `request' move, and state <2> in *Figure 2* preceding the `promise' is characterized by the fact that both participants have reached a mutually accepted understanding of the `request', e.g.: `"Who organized the workshop?"` `"Which workshop?` `"The Intelligent Interface workshop."` (complex `request' move) `"It was Professor`

`Feiner.` (`inform').

(§38) A second schema type is employed for `inform' and `assert' moves (*Figure 5*). (For the present purpose, the difference between `inform and `assert' may be ignored.) An `inform' move, for example, always starts with a single atomic `inform'. Next, there are the following options:

- a `jump' to the final state of the `inform' move (immediate return to the embedding structure);
- an embedded dialogue initiated by B, who wants to solicit context information, This dialogue has the function to solicit context information for the `inform'; e.g., `..."It was Professor Feiner."` `"Do you mean Steven Feiner?` `"Yes, Steven Feiner from Columbia University."` It follows exactly the same rules as the main dialogue, that is, a new instantiation of the *dialogue* schema (*Figure 2*) is traversed. However, during this embedded dialogue, the dialogue participants have changed their roles as information seeker and information provider (indicated by reversing the order of the parameters (B, A) of the transition label).

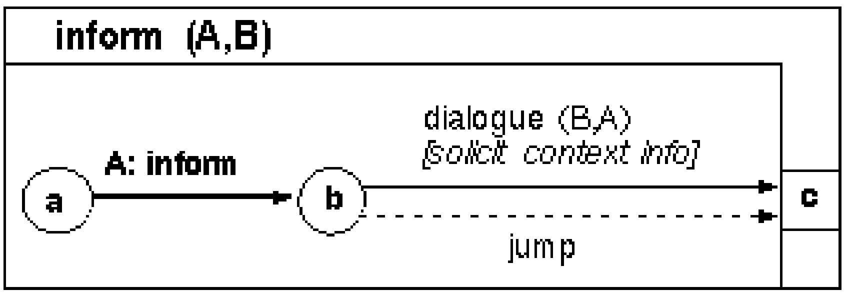


Figure 5: Schema for `inform' moves (analogous `assert')

(§39) The move schema of a `request' is shown in *Figure 6*. This is the most general schema type, i.e., it applies to all of the COR moves except `promise', `accept', `inform', and `assert'. Now, the `request' transition <1-2> in the basic dialogue schema (*Figure 2*) is to be interpreted as follows: In order to perform a `request', actually the `request' schema of *Figure 6* has to be traversed - state <a> is mapped onto <1>, state <c> onto <2>, and in between <1> and <2> several things may happen which in their entirety serve the same purpose as an atomic `request' (A wants B to do some action, i.e., in our context B is to search for the requested information and present it to A).

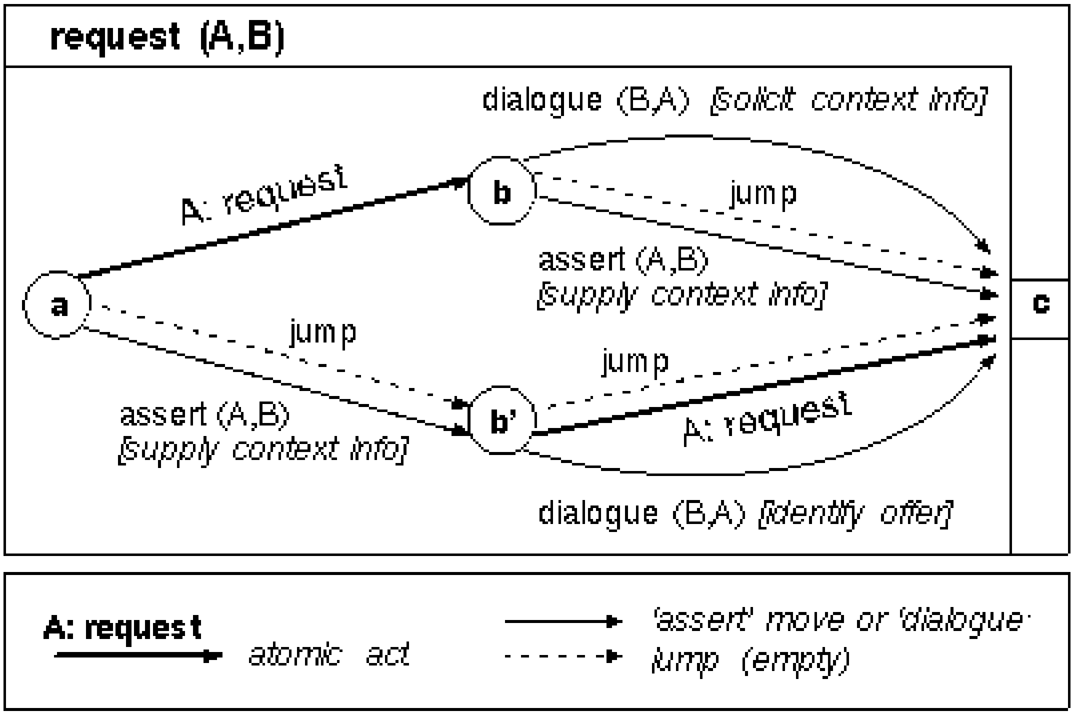


Figure 6: Schema for `request' moves

(§40) When A intends to perform a `request', he can take one of two paths: <a-b-c> or <a-b'-c>. The first path <a-b-c> starts with an atomic `request' followed by one of several options:

- no explicit action (the transition <b-c> being a `jump'). Thus, the `request' move consists of a single atomic act, which was the sole case we could account for before we introduced the move schemata;
- another complex move supplying context information - an `assert', which has the same structure as the `inform' in a dialogue (*Figure 5*);
- a dialogue initiated by B. This may happen when B believes he has identified the request, but to be able to accept or reject the request B needs further information; e.g., `"Why are you asking this?"` `"Because I want to submit a paper."` As in the embedded dialogue of the `inform/assert' schemata, the reversed order of the parameters `A' and `B' indicates that A and B have temporarily exchanged their roles as information seeker and information provider.

(§41) In the second path <a-b'-c>, A may start with an `assert' supplying context information for a yet undefined `request' (<a-b'>; e.g., `"I want to submit a paper."`). After that, there are three options:

- The `assert' may be followed by an explicit `request' (<b'-c>; e.g., `"Which is the next big AI conference?"`).
- If A does not add such a `request' voluntarily, B may still be able to reconstruct the meaning of the implicit `request' out of the information gained from A's `assert', or at least build a reasonable hypothesis (e.g., that a suitable conference or publisher is being looked for). B can do this tacitly - `jump' <b-c'>, so that the `request' contribution is complete. Actually, A's `assert' is then usually called an *indirect speech act*. Some indirect speech acts are therefore accounted for by the COR model.
- B recognizes that A has supplied context information for a `request', but B is not able to reconstruct the specific meaning of the `request' proper. B may then ask for information about A's

`request', that is, initiate a subdialogue. For example, he may start by asking `"How can I help you? I don't see what you want me to do exactly"`.

The schemata for `offer', `withdraw ...', `reject ...', and `evaluate' (<4-1>, <4-5>) are of the same form (i.e., in *Figure 6*, "request" has to be replaced by the corresponding label).

(§42)

3.4.2 Functional view

Each atomic act or complex move serves a particular function (illocutionary force) for the dialogue as a whole: requesting or offering, providing information, etc., in an expected course of action; rejecting and retracting role expectations in unexpected courses of actions.

(§43) Likewise, the components of a single move have particular functions with respect to the whole move. We have identified two main types of components exerting two types of functions:

- One component type is the carrier of the illocutionary force of the complete move. Typically, it is an atomic dialogue act (transition <a-b> in *Figure 6*, e.g., the request `"Show me all IR conferences in 1991!"`), but it may also be realized as an embedded dialogue (transition <b'-c> in *Figure 6*, e.g., `"Which conferences are you interested in?"` `"All IR conferences in 1991."`)
- The other component type carries information that is less significant and only *supports* the illocutionary force of the complete move. Its own force is always *assertive* (informing). Some transitions in *Figure 6* are of this type, e.g., `"I want to get an overview."` (= `assert' (A, B) [supply context information]);
  `"Why do you ask?"` `"Because I want to get an overview.` (= `dialogue' (A, B) [solicit context information]).

(§44) In accordance with "Rhetorical Structure Theory" by Mann and Thompson [1987a, b], we call a component of the first type the "*nucleus*", a component of the second type the "*satellite*" of the move. The different functional status of the components is called "*nuclearity*". Similarities and differences with Mann and Thompson's theory will be discussed in *Section 4.1*. With the help of this distinction we can handle some indirect speech acts.

(§45) These functional aspects - the distinction between nucleus and satellite - add to the various illocutionary functions discussed for the basic schema in *Section 3.2*, and they are at the core of the extensions we have proposed. Although we analyzed only information-seeking dialogues, we believe that the partitioning into these two functions is a very general phenomenon that a comprehensive dialogue model must account for. The structural realization, however, seems to be much more genre-sensitive, and our theoretical approach permits minor changes to the dialogue move networks, as long as they preserve the functional distinctions. A computational model to be used for the access to information systems must reflect these functional aspects in order to regulate the embedding of context information for clarification, for enhancement of understanding, and the like.

(§46)

3.5 Structure of the example dialogue

Now that the complete model has been introduced, we are able to present an analysis of the dialogue in *Example 3*. We interpret the dialogue and move schemata as a recursive transition network, which produces as its output a hierarchical *trace* as the dialogue evolves. Thus, we present the result of the analysis as a tree structure (*Figure 7*).

(§47) Note that the RTN is not traversed in the same way as a sentence grammar: Sentence grammars are *synoptic*, i.e., there is a single final product after the generation or analysis. Discourse grammars have to be *dynamic*, i.e., meaningful structures are built up continuously *during* traversal [Martin, 1985; cit. from Fawcett *et al*., 1988]).

The hierarchical structure of the example dialogue can be described in terms of our model as follows:

<table>
<tr><th colspan="7">dialogue (A,B) ...</th></tr>
<tr><td>1
request
(A,B)</td><td>2
promise
(B,A)</td><td>3
inform
(B,A)</td><td>4
evaluate
(A,B)</td><td>5
request
(A,B)</td><td colspan="2">6
reject request (B,A)</td></tr>
<tr><td rowspan="2">A: request
Where does the next IJCAI take place?</td><td rowspan="2">jump</td><td rowspan="2">B: inform
In Australia.</td><td rowspan="2">jump
<4-1></td><td rowspan="2">A: request
But where in Australia?</td><td rowspan="2">B: reject
I don't know,</td><td>assert
(B,A)</td></tr>
<tr><td>B: assert
I don't have that documented.</td></tr>
</table>

<table>
<tr><th colspan="6">... dialogue (A,B) ...</th></tr>
<tr><td colspan="5">7
offer (B,A)</td><td>8
accept (A,B)</td></tr>
<tr><td rowspan="3">B: offer
But I can show you the CfP.</td><td colspan="4">dialogue (A,B) [solicit context information]</td><td rowspan="3">A: accept
OK.</td></tr>
<tr><td>request
(A,B)</td><td>promise
(B,A)</td><td>inform
(B,A)</td><td>evaluate
(A,B)</td></tr>
<tr><td>A: request
What for?</td><td>jump</td><td>B: inform
Maybe you can find it there.</td><td>jump
<4-1></td></tr>
</table>

<table>
<tr><th colspan="7">... dialogue (A,B)</th></tr>
<tr><td colspan="5">9
inform (B,A)</td><td colspan="2">10
evaluate (A,B)</td></tr>
<tr><td rowspan="4">B: inform
Here it is.</td><td colspan="4">dialogue (A,B) [solicit context information]</td><td rowspan="4">A: evaluate
<4-5>
Ok,</td><td>assert
(A,B)</td></tr>
<tr><td colspan="2">request (A,B)</td><td colspan="2">reject request (B,A)</td><td rowspan="3">A: assert
I'll take the time to read it in peace.</td></tr>
<tr><td>assert
(A,B)</td><td rowspan="2">A: request
Where is the best place to look?</td><td>assert
(B,A)</td><td rowspan="2">jump</td></tr>
<tr><td>A: assert
The document is too long.</td><td>B: assert
It could be anywhere in the document.</td></tr>
</table>

Figure 7: Structure of the example dialogue 3

(§48)

- The first cycle through the dialogue network (1-4) contains a `request' and an `inform' move, which consist of the respective atomic acts only, i.e., the nuclei without satellites; `promise' and `evaluate' are implicit (jumps).
- The next cycle (5, 6) consists of a nuclear `request' and a complex `reject request'.
- The last cycle (7-10) is the most complexly structured one, starting with an `offer' move and ending with a positive evaluation, indicating that the whole dialogue was considered successful by the information seeker (A).
- The `offer' move (7) consists of B's `offer' nucleus (`"But I can show you ..."`) plus a subdialogue initiated by A: `"What for?"`. Obviously, A has not quite understood the purpose of the offer, and desires more information before being able to accept (8) the offer.
- Now B can present the offered information: The `inform' (9) is composed of the utterance `"Here it is"`, which accompanies B's presenting a document, and of a subdialogue. Here, A requests assistance for scanning the document (`"The document is too long. Where is the best place to look?"`). B's reply `"It could be anywhere in the document"` is no answer to the request (where to look), but it is interpreted here as an *indirect* `reject request' meaning `"I cannot answer this question"`. However, A seems to understand the meaning of this *indirect speech act* out of the dialogue context, as is obvious from his reply.
- A realizes that no further assistance for scanning the document can be expected, and utters `"OK, I'll take the time to read it in peace."` (10) Note that the `"OK"` is backed up by an `assert' (the satellite of the positive evaluation). A utters it voluntarily, perhaps wanting to make his intention clear at this point. Otherwise, a simple `"OK"` might have been ambiguous and B perhaps would have tried to clarify it by another subdialogue.

(§49) The analysis of the small example dialogue illustrates how the major phenomena pointed out in *Section 3.3* are treated by the extended dialogue model:

- implicit dialogue moves: omission of the utterance;
- backing up by contextual information: distinction between nucleus and satellite;
- indirect speech acts: omission of the nucleus;
- postponing one's response to a dialogue act: entering a subdialogue that is interpreted as a satellite of this dialogue act.

(§50)

4 Discussion

4.1 Related work in systemic-functional linguistics

Our general conception of information-seeking dialogues is based on the assumption that the participants act cooperatively and negotiate commitments following conversational conventions and typical role patterns. Analogous to the "Conversation for Action" model of Winograd and Flores [1986], this notion of commitment is central to our model, and has been adapted to the case of information-seeking dialogues resulting in our basic COR dialogue schema. We extended this schema in order to cover phenomena that we termed "nuclearity" and "functional equivalence" of atomic dialogue acts and complex moves. How these phenomena are treated by discourse models in computational linguistics - in particular, in the "systemic-functional" tradition - is outlined in this section. Our perspective concerning the *whole dialogue* is rather similar to that of Fawcett *et al*. [1988], whereas the *internal structuring of single dialogue moves* has much in common with Mann and Thompson's [1987] Rhetorical Structure Theory.

(§51) Fawcett et al. have developed a grammar for unrestricted natural language dialogues. It describes complete dialogues (exchanges), the components of a dialogue (moves), and the dialogue acts which are components of the moves. The work of Fawcett *et al*. is in the tradition of systemic-functional linguistics [cf. Halliday, 1985] and uses "systemic networks" as a means for description. These systemic networks represent the sequential or parallel *decisions* which are made to perform a single move during the dialogue. In addition, Fawcett *et al*. have integrated flowchart elements in order to represent the temporal relations *between* subsequent moves, as well as between subsequent components of one move. This is achieved by modeling the respective role changes of speaker and hearer in detail.

(§52) In the view of Fawcett *et al*., moves are composed of a "head act" and preceding "starter" or following "continuer acts". The head act may remain implicit (not verbalized) in case the hearer is able to reconstruct its meaning. However, the relation between the head act and associated starter/continuer acts is not further elaborated by them. Their model also permits embedded (sub)dialogues, e.g., for the purpose of requesting explanations for a statement.

(§53) Major parallels to our approach include the following aspects:

- distinction between the illocutionary level and the thematic-semantic aspects of dialogue, and concentration on the illocutionary aspects;
- equivalent function of acts and moves for the dialogue development;
- nested subdialogues;
- the concept of nuclearity (prominent status of the head act);
- possible omission of the head act.

(§54) For a thorough description of the structure of dialogue moves and the interrelations between their subparts, which is rather neglected by Fawcett *et al*., the "Rhetorical Structure Theory" (RST) of Mann and Thompson [1987a, 1987b] can make significant contributions.

(§55) RST has explicitly been developed for the analysis of written *texts*, i.e., texts which are produced by *one* author. Nevertheless, even in the context of modeling dialogues we consider a text model relevant: One can argue that written text is a special kind of communicative act (also stated by Fawcett *et al.* [1988]), differing only in complexity and extent from dialogue acts. Texts and their components can be analyzed with respect to the effects they try to produce. Mann and Thompson analyze texts with various illocutionary forces, e.g., essays which have a purely informative character and can be seen as complex assertions, or advertising texts which have a more demanding impact and can be taken as complex requests. In cooperative dialogues, the dialogue acts may be more simple because the hearer has the chance to produce direct feedback, whereas in texts/monologues, the possible reactions of the hearer are to be anticipated by the author.

(§56) In RST, the general unit of description is the "text span". The entire text, being a text span itself, can be decomposed recursively into at least two subspans up to the primitive (atomic) text spans (e.g., phrases). Normally, the subspans have different status: One of them is the "nucleus" containing the *point* of the text span. This is reminiscent of the "head" of a dialogue move in the view of Fawcett *et al*. mentioned above. In addition, in RST there exists at least one "satellite" with the function of increasing the probability of success of the nucleus - depending on the illocutionary point/force, the addressee's readiness to believe, accept, understand, etc.

(§57) Meaningful *links* between the subspans are described as *rhetorical relations*, which build up text coherence. Mann and Thompson believe that virtually all texts can be completely analyzed by using a set of about 20 types of rhetorical relations they have defined. Normally, the rhetorical relations are asymmetric (reflecting the different status of the associated text spans). If, for instance, it is intended to convince the reader of an assertion (expressed by the nucleus) the satellites might contain the "evidence"; if an action of the reader is requested the author might tell why he feels entitled to do so ("justification"), give reasons ("motivation"), or he might supply the prerequisites for the action ("enablement").

(§58) The relations between RST and our work can be summarized as follows:

- The notion of "nuclearity" in our COR model is adopted from RST. Move components possess an unequal status and an unequal function. The component designating the move *type* is the nucleus and carries the illocution. The other component is the satellite and raises the probability of success of the nucleus.
- In our model two main types of schemata - for dialogues and moves - are recursively used in order to segment the whole dialogue (i.e., dialogues are split into moves, which are again split into (sub)dialogues, other moves, or atomic acts). In contrast, RST employs recursion of only one schema type, corresponding to our dialogue move schemata; whereas *subdialogues* with role changes between speaker/addressee or information seeker/provider are not discussed in a text theory, of course. In our view, subdialogues within a dialogue move have the same function for the superordinate dialogue contribution/move as subspans in an RST analysis have for the textspan.
- RST as a model of *texts* may afford to neglect indirect speech acts. Mann and Thompson [1987a] have only demonstrated the loss of coherence for written texts when nuclei are deleted. For the dialogue case, however, omission of nuclei seems to be an appropriate description model for at least some indirect speech acts. A related point is made by Fawcett *et al.* [1988], who state that the *head* act of a move may be omitted if it is reconstructable.
- RST and other related approaches in the field of text planning have done extensive research on the definition of discourse structure relations (for an overview see Hovy and Maier [1991]). At present, supply/solicit "context information" is the only term that we use in the COR model to

designate the relation between satellite and nucleus of a dialogue move. In analogy to rhetorical relations, we intend to develop subcategories in order to achieve more specific descriptions of the different rhetorical functions of the satellites, taking into account the characteristics of the information-seeking situation.

(§59)

4.2 Current work

We are working on an extension of the illocutionary modeling layer by incorporating rhetorical and thematical aspects; and second, on the integration of such a multi-layered dialogue model into information system prototypes under development at GMD-IPSI .

(§60) As mentioned in the beginning, the COR model presented here covers the illocutionary aspects of dialogue contributions, abstracting away from their propositional content. Thus, it describes possible dialogue structures and processes with respect to the conversational tactics of the two participants. However, when concrete dialogue contributions are to be *planned* or *generated* (e.g., by an intelligent dialogue system), content aspects are certainly important. We intend, on the one hand, to refine the illocutionary model by defining possible types of rhetorical relations between the components of a move (nucleus and satellite). This would bridge the gap between the illocutionary and the content-oriented aspects. On the other hand, the implementation of a dialogue manager requires the combination of our model with other models that are orthogonal to the illocutionary layer, providing criteria for the *relevance of the contents* of cooperative dialogue contributions [Thiel, 1990]. Additionally, a case-based approach is pursued to cover domain-dependent global structures of information retrieval dialogues [Tißen, 1991].

(§61) The incrementally developed model is to be integrated into our current dialogue system prototype. The interaction mode of the such revised system will comprise graphical input and output (graphical presentations of retrieval results), and restricted natural language output. Based on the COR model the choice and supply of interaction means will be determined by the type of dialogue contributions, the distinction between expected and alternative responses, and the rhetorical relations between components of dialogue moves. For instance, an `accept' of an offer, which does not introduce a new propositional content (*Table 1*), should be presented in a different way than a `request', the content of which is decisive for the course of the subsequent dialogue; and context information or meta-information should be generated as natural language output (see the PENMAN project [1989] and Bateman *et al.* [1991] for a description of the text generation system to be employed). A major point will also be the adequate presentation of the dialogue structure of an ongoing dialogue itself.

(§62)

5 Summary and conclusions

A generic, dynamic dialogue model describing the illocutionary aspects of information-seeking *dialogues* and the contained *moves* was presented. The COR model distinguishes between two types of functions, i.e., functions of the moves for the dialogue, and functions of the move components for the move. The first type is best described by the notion of negotiation of commitments (e.g., to commit oneself to provide relevant responses in a given dialogue situation and context, or to withdraw from a commitment without being non-cooperative).

(§63) As the intention of a move may fail, it is often necessary to raise its *probability of success*. This is addressed by the second type of function. Most moves may consist of two components: One is the "nucleus", carrying the function of the whole move for the dialogue. The other one is a "satellite" component, giving an appropriate kind of context information (e.g., explain the meaning of a term in a question, give reasons for the rejection of a question, explain why an answer is relevant).

(§64) Both components may be performed in different ways: They may be simple utterances or composite moves, or embedded subdialogues, or they may be omitted. For example, if a question is considered understandable, no further explanation is needed.

(§65) The COR dialogue model is intended to hold for cooperative, matter-of-fact information-seeking dialogues - in contrast to other genres such as narrative everyday conversations, small talk, sales or business talks, arguments, etc. The development of the model was based on empirical analyses of information-seeking dialogues between humans which fulfilled these criteria. However, we believe that our conception can also be applied to the case where the role of the information provider is taken by an intelligent dialogue manager that controls the interaction with an information system.

(§66) So far, the model is descriptive and intended to cover as many dialogue phenomena encountered as possible. As soon as it is taken as a basis for the design of an intelligent dialogue interface, the designer has to specify which of the possible dialogue steps are to be realized under which conditions. This also depends on the functionality of domain dependent system components.