The DIT++ taxonomy for functional dialogue markup

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ABSTRACT

This paper presents the DIT^{++} taxonomy of communicative functions, with some of its background and theoretical motivations. Its applications in dialogue annotation, dialogue generation, dialogue management, and theoretical dialogue research are summarized, and its role is indicated in a recently started effort of the ISO organization to develop an international standard for functional dialogue markup.

1. DIALOGUE ACTS

Dialogue acts are widely used in studies of dialogue phenomena, in dialogue annotation efforts, and in the design of dialogue systems. The very idea of describing dialogue in terms of communicative actions, such as questions, promises, requests, and greetings, goes back to speech act theory (Austin, 1962; Searle, 1969), which has been an important source of inspiration for modern dialogue act theory. Where speech act theory is primarily a theoretical orientation in the philosophy of language, however, dialogue act theory is a data-driven approach to the computational modeling of interactive language use. As a way to describe meaning in communicative behaviour, dialogue acts are semantic concepts that can be defined by the way a dialogue act is intended to affect the information state of an addressee when (s)he understands the behaviour. For instance, when an addressee understands the utterance *Do you know what time it is?* as a question about the time, then the addressee's information state is updated to contain (among other things) the information that the speaker does not know what time it is and would like to know that. If, by contrast, an addressee understands that the speaker used the utterance to reproach the addressee for being late, then the addressee's information state is updated to include the information that the speaker does know what time it is. Distinctions such as that between a question and a reproach refer to the *communicative function* of a dialogue act; the entities, their properties and relations that are referred to, constitute its *semantic content*. The communicative function of a dialogue act expresses what the speaker is trying to achieve, and the semantic content describes the information that is being addressed. Another way of characterizing this distinction is that the communicative function of a dialogue act specifies how the semantic content is to be used to update an information state.

The term 'dialogue act' is often used in the rather loose sense of 'speech act used in dialogue', but such a characterization hardly does justice to the semantic status of dialogue acts. A more accurate characterization could run as follows. *A dialogue act is a unit in the semantic description of communicative behaviour in dialogue, specifying how the behaviour is intended to change the information state of a dialogue participant who understands the behaviour correctly* (i.e. as intended by the speaker). The semantic content of a dialogue act is the information with which the information state is to be updated; the communicative function specifies the way in which that information is to be used in updating the information state. Formally, a dialogue act is an information-state update operator construed by applying a communicative function to a semantic content.

The assignment of meaning to stretches of communicative behaviour in dialogue presupposes a way to identify stretches that are meaningful. The identification of such stretches is called the segmentation of the dialogue. Dialogue segmentation has many intricacies, the discussion of which is beyond the scope of the present paper; see e.g. Larsson (1998); Geertzen et al. (2007). In this paper we will use the theory-neutral term 'markable' to indicate stretches of communicative behaviour that express one or more dialogue acts, and that are the object of dialogue act markup.

Dynamic Interpretation Theory (DIT) is a computational approach to the analysis of the meaning of dialogue utterances in natural human dialogue or in human-computer interaction, with a focus on the functional aspect of utterance meaning.[1] Like Speech Act Theory, Communicative Activity Theory (Allwood, 2000), and Grice's theory of cooperative action, DIT approaches the use of language as action, but different from these and other theories, DIT considers utterances as expressing multiple update actions on an addressee's as well as on the speaker's information state.DIT does not consider purely linguistic utterances only, but also nonverbal communicative behaviour, such as head gestures and facial expressions, or graphical acts like showing an hour glass on a computer screen, and 'multimodal utterances' where language is combined with nonlinguistic sounds, where prosodic aspects of speech are taken into account, and where linguistic and nonverbal elements are used in synchrony in order to perform one or more dialogue acts.

One of the outcomes of the development of DIT has been a taxonomy of communicative functions which in recent years has been extended and modified, taking into account a range of other taxonomies that have been proposed, and resulting in a comprehensive general-purpose taxonomy called the DIT^{++} taxonomy. This taxonomy has been applied in human annotation, in machine anno-

Cite as: Title, Author(s), *Proc. of 8th Int. Conf. on Autonomous Agents and Multiagent Systems (AAMAS 2009)*, Decker, Sichman, Sierra and Castelfranchi (eds.), May, 10–15, 2009, Budapest, Hungary, pp. XXX-XXX.

[1] See Bunt, 1989; 1990; 1994; 1995; 2000; 2004; 2006; 2008; Bunt et al., 2007; Bunt & Girard, 2005; Geertzen, 2009; Geertzen & Bunt, 2006; Keizer & Bunt, 2006; 2007; Morante, 2007; Petukohva & Bunt, 2009

tation, and in the design and implementation of modules for dialogue management and generation in multimodal dialogue (the PARADIME system, see Keizer & Bunt, 2006; 2007). In the European project LIRICS, a slightly simplified version of this taxonomy has been defined and tested for its usability to the annotation of dialogues in several European languages.

This paper is organized as follows. In the next section we discuss the definition of communicative functions and the multifunctionality of dialogue utterances. Section 3 discusses the structural organization of dialogue act taxonomies, in particular the clustering of communicative functions into dimensions. A notion of dimension is introduced which has a conceptual significance, and goes beyond that of a cluster of mutually exclusive tags. Section 4 describes the structure of the DIT^{++} taxonomy, with its general-purpose and dimension-specific functions. Section 5 briefly discusses some of the applications of the DIT^{++} taxonomy, including its role in a recently started ISO project that aims at establishing an international standard for functional dialogue markup.

2. COMMUNICATIVE FUNCTIONS

2.1 Defining Communicative Functions

Existing markup schemes for communicative functions use either one or both of the following two approaches to defining communicative functions: (1) in terms of the intended effects on addressees; (2) in terms of properties of the signals that are used. For example, questions, invitations, confirmations, and promises are nearly always defined in terms of speaker intentions, while repetitions, hesitations, and dialogue openings and closing are typically defined by their form. Defining a communicative function by its linguistic form has the advantage that their recognition is relatively straightforward, but faces the fundamental problem that the same linguistic form can often by used to express different communicative functions. For example, the utterance *Why don't you start?* has the form of a question, and can be intended as such, but can also be used to invite someone to start. Form-based approaches of dialogue acts are also in danger of confusing purely descriptive concepts with semantic ones, since descriptions like 'repetition' and 'hesitation' say something about the form of the behaviour, but don't say anything about the meaning of that behaviour.

DIT takes a strictly 'deep', semantic approach to dialogue acts in terms of the effects on addressees that a speaker intends to occur as the reflection of understanding the speaker's behaviour. Two caveats, though. First, speakers are not conscious of all their intentions when they perform dialogue acts. Definitions in terms of intended effects should therefore not be taken to imply that dialogue participants are necessarily *aware* of the intentions that are ascribed to them by a dialogue act analysis. Second, while we do not take linguistic form to be part of the definition of a communicative function, we do insist that every communicative function which occurs in a taxonomy must be empirically justified, in the sense that there are ways in which a speaker can indicate that his behaviour should be understood as having that particular function through the form of his behaviour. This requirement puts communicative functions on an empirical basis.

The distinction between deep and more shallow approaches is relevant in connection with the different requirements of human and automatic annotation. Human annotators are better at understanding and annotating dialogue utterances in a detailed manner, because they have more knowledge of intentional behaviour and they have richer context models. Since a general dialogue annotation schema should support human annotation, it should contain concepts with a depth and granularity that matches human understanding of the functions of dialogue utterances. In order to support automatic annotation, on the other hand, the schema should also contain concepts that are suitable for a more shallow form of annotation, that relies less more on surface features and less on deep semantic knowledge. These two requirements can be met by defining hierarchies of communicative functions, where functions deeper down in a hierarchy correspond to more specific intentions or assumptions on the part of the speaker than functions higher in the hierarchy.

2.2 Multifunctionality

Studies of human dialogue behaviour indicate that natural dialogue utterances are very often multifunctional. This is due to the fact that participation in a dialogue involves several activities beyond those strictly related to performing the task or activity for which the dialogue is instrumental (such as obtaining certain information, instructing another participant, negotiating an agreement, etc.). In natural conversation, among other things, dialogue participants constantly "evaluate whether and how they can (and/or wish to) continue, perceive, understand and react to each other's intentions" (Allwood, 1997). They share information about the processing of each other's messages, elicit feedback, and manage the use of time and turn allocation, of contact and attention, and of various other aspects. Communication is thus a complex, multi-faceted activity, and for this reasondialogue utterances are often multifunctional. A qualitative and quantitative analysis of this phenomenon (Bunt, 2007; 2009) shows that the multifunctionality of minimal functional segments in spoken dialogue on average amounts to 4-5 functions. For multimodal dialogues, where significant parts of the interaction is performed through nonverbal behaviour, the multifunctionality is even greater.

One of the requirements on a dialogue act taxonomy is that it should support the multifunctional analysis and specification of dialogue, and preferably do this in a way that explains the multifunctionality that is observed in natural dialogue.

3. DIALOGUE ACT TAXONOMIES

3.1 Taxonomy structures

Existing dialogue act taxonomies differ not only in their precise sets of tags, but more importantly with respect to (1) the underlying approach to dialogue modeling; (2) the definitions of the basic concepts; (3) whether the tags are mutually exclusive; (4) the coverage of aspects of interaction; and (5) the level of granularity of the defined tag set. Generally, dialogue act taxonomies can be divided into one- and multidimensional ones.

One-dimensional schemes have a set of mutually exclusive tags, and support coding dialogue utterances with a single tag. Their tag sets are often quite small (such as the LINLIN schema (Ahrenberg et al., 1995) and the HCRC schema (Carletta et al., 1996)), and have the form of a simple flat list. The simplicity of these tag sets is usually considered to make them more reliable and to take less effort to apply consistently by annotators. It has been noted, however, that one-dimensional annotation schemas also have serious disadvantages (see e.g. Klein et al., 1998; Larsson, 1998; Popescu-Belis, 2005), in particular in view of the pervasive multifunctionality of natural dialogue behaviour.

Multidimensional taxonomies support dialogue utterances to be coded with multiple tags and have a relatively large tag set; see e.g. Allen & Core (1997), Larsson (1998); Popescu-Belis (2005), Bunt (2006); Bunt & Schiffrin (2006). Such a large tag set would benefit in several respects from having some internal structure.

First, clustering semantically related tags improves the transparency of the tag set, as the clusters indicate the kind of semantic information that is considered. The introduction of clusters of tags also makes the coverage of the tag set clearer, since the clusters will often corresponds to certain classes of dialogue phenomena.

Second, a taxonomical structure which is based on semantic clustering may support the decision-making process of human annotators: an initial step in such a process can be the decision to consider a particular cluster, and subsequently more fine-grained distinctions may be tested in order to decide on a specific tag within the cluster. Also, the tags within a cluster are typically either mutually exclusive (such as 'signal understanding' and 'signal non-understanding'), or are related by an entailment relation (such as a 'confirmation' also being an 'answer'); in both cases, an annotator should choose only one tag from the cluster. In this way the organisation of the tag set supports annotators in avoiding the consideration of inconsistent or irrelevant combinations of tags.

Third, a hierarchical organisation in the tag set may also be advantageous for automatic annotation and for achieving annotations which are compatible though not identical with those of human annotators. The choice of a particular cluster of tags can typically be made on the basis of less information than that of a particular tag within the cluster. The same is true for choosing a more general tag from the cluster versus a more specific tag (e.g. 'answer' versus 'disconfirmation'). Human (expert) annotation is often more detailed than automatic annotation because of the difference in semantic information that is effectively available. Automatic and human annotation are therefore often not identical, but still may be highly compatible. This can be expressed and measured precisely by taking the semantic relations within a cluster into account for computing annotator-agreement scores (Geertzen & Bunt, 2007). A structured tag set can be searched more systematically (and more 'semantically') than an unstructured one, and this can clearly have advantages for dialogue annotation, interpretation, and generation.

3.2 Clustering and Dimensions

The clusters of communicative functions that can be found in existing annotation schemes are typically characterized by notions of intuitive conceptual similarity, such as the clusters of questions and statements called 'info-request' and 'statement' in the DAMSL taxonomy.

DAMSL (Dialogue Act Markup using Several Layers) is the first and most frequently used annotation scheme that implements the multidimensional approach (Allen & Core, 1997), allowing multiple labels to be assigned to utterances in four layers: Communicative Status, Information Level, Forward-Looking Function (FLF) and Backward-Looking Function (BLF). The FLF layer is subdivided into seven classes, including (roughly) the classes of commissive and directive functions, well known from speech act theory; the BLF layer has four classes, as shown in Table 3.2.

These classes are also referred to as 'dimensions' (Core and Allen, 1997). While the DAMSL documentation does not discuss the notions of 'layer' and 'dimension' as such, the various ways of clustering the tag set are clearly useful for introducing some structure in the tag set and for providing annotation guidelines that can benefit from this structure. Clusters or 'dimensions' like those in DAMSL are usually defined as a set of mutually exclusive functions, related to the same type of information, such as the set {opening, closing} that constitutes the dimension called 'conventional'. Bunt (2006) has shown that this approach to clustering does not always lead to a notion of dimension that has any conceptual and theoretical significance, and that provides a consistent account of the observed multifunctionality of dialogue utterances.

Layer	*Dimension*
Forward-Looking Functions	statement
	info-request
	influencing-addressee-future-action
	committing-speaker-future-action
	conventional
	explicit-performative
	exclamation
	other-forward-function
Backward-Looking Functions	agreement
	understanding
	answer
	information-relation

Table 1: Layers and dimensions in DAMSL.

Popescu-Belis (2005) argues that dialogue act tagsets should seek a multidimensional theoretical grounding, and defines the following aspects of utterance function that could be relevant for choosing dimensions: (1) the traditional clustering of illocutionary forces in speech act theory into five classes: Representatives, Commissives, Directives, Expressives and Declarations; (2) turn management; (3) adjacency pairs; (4) topical organization in dialogue; (5) politeness functions; and (6) rhetorical roles.

Bunt (2004; 2006) suggests that a theoretically grounded multidimensional schema should be based on a theoretically grounded notion of dimension, and proposes to define a *set of dimensions* as follows.

(1) Each member of a set of dimensions is a cluster of communicative functions which all address a certain aspect of participating in dialogue, such that:
   1. dialogue participants can address this aspect through linguistic and/or nonverbal behaviour which has this purpose;
   2. this aspect of participating in a dialogue can be addressed independently of the other aspects corresponding to elements in the set of dimensions, i.e., an utterance can have a communicative function in one dimension, independent of its functions in other dimensions.

The first of these conditions means that only aspects of communication are considered that can be distinguished according to empirically observable behaviour in dialogue. The second condition requires dimensions to be independent, 'orthogonal'. A set of dimensions that satisfies these requirements can be a good foundation for a multidimensional annotation scheme, especially if the set of functions within each dimension is defined in such a way that any two functions are either mutually exclusive or have an entailment relation, since it would follow that a markable can be annotated with (maximally) as many tags as there are dimensions, one function (at most) for each dimension.

Note that the use of an information-state update semantics for dialogue acts, as underlying DIT, is helpful when designing a multidimensional taxonomy, because it supports the formulation of precise definitions of communicative functions, clarifying the relations between them and providing a formal basis for what may intuitively seem to be sets of related functions, and thus for identifying potential dimensions.

Petukhova (forthc.) provides an up to date survey of the use of communicative functions related to various dimensions in 18 existing annotation schemas. She presents test results, based on co-occurrence frequencies, phi-statistics, and vectorial distance measures to empirically determine to what extent proposed dimensions

are well-founded. One of the conclusions from this study is that the dimensions of the DIT^{++} taxonomy, described below, do indeed form a well-defined set of dimensions.

3.3 General-purpose and dimension-specific functions

When we view a dimension in dialogue analysis or specification as a particular aspect of interacting, like topic management, turn management, or trying to perform a certain task, then we see that dialogue acts like questions and answers do not belong to any dimension. One can ask a question about something in the task, or a about agreeing to close a topic, or about whose turn it is to say something, or about any other aspect of interacting, so questions can be said to belong to *all* these dimensions. Similarly for answers, statements, requests, offers, agreements, (dis-)confirmation, and so on. Clusters of general such dialogue acts, which belong to what in speech act theory are sometimes called *core speech acts*, therefore should not be considered as forming certain dimensions, but as *general-purpose functions* that can be used in any dimension. This in contrast with communicative functions that are specific for a particular dimension, such as Turn Keep, Turn Release, Introduce Topic, Change Topic, Apology and Thanking. On this view, which has been developed in DIT, a taxonomy of communicative functions consists of two parts:

1. a set of clusters of *general-purpose functions*;
2. a set of clusters of *dimension-specific functions*.

For the DIT^{++} taxonomy, Table 4.1 shows the structure of the first part (the general-purpose functions) with the main functions in the various clusters; the complete set of functions is shown in Annex A. Table 4.1 lists examples of dimension-specific communicative functions in each of the DIT^{++} dimensions; the complete taxonomy of dimension-functions is shown in Annex A.

General-purpose functions can be used to build a dialogue act in any dimension, depending on the type of semantic content that such a function is combined with. Therefore an adequate annotation or specification of a markable should in general have two components: the communicative function and the dimension that is addressed, as in the following examples. (If the communicative function is a dimension-specific function, then the specification of the dimension is redundant, if the names of these functions have been chosen to be unique.)

(2) a. Please repeat that.
<Feedback, Request>

b. Jim, your turn.
<Turn Management, Instruct>

c. I am very grateful for your help
<Social Obligations Management, Inform>

d. You got that?
<Allo-Feedback, CheckQuestion>

4. DIT++ DIMENSIONS AND FUNCTIONS

4.1 General-purpose functions

The general-purpose communicative functions in the DIT^{++} taxonomy fall into two broad categories:

- the *Information Transfer* functions, which aim at seeking or providing information, and are subdivided accordingly in *information seeking* (or 'questioning') and *information providing* functions;

– *Information Transfer Functions*
– *Information-Seeking Functions*
– *Direct Questions*
– propositional question, set question, alternatives question, check question, etc.
– *Indirect Questions*
– indirect propositional question, set question, alternatives question, check question, etc.
– *Information-Providing Functions:*
– *Informing Functions:*
– inform, agreement, disagreement, correction;
– *Informs with Rhetorical or Attitudinal Functions, such as* elaboration, justification, exemplification.. and warning, threat,..
– *Answer Functions:*
– propositional answer, set answer, confirmation, disconfirmation
– *Action Discussion Functions*
– *Commissives*
– offer, promise, address request
– *other commissives, expressable by means of performative verbs*
– *Directives:*
– instruction, address request, indirect request, (direct) request, suggestion
– *other directives, such as advice, proposal, permission, encouragement, urge,..., expressable by means of performative verbs*

Table 2: Structure of the DIT^{++} taxonomy of general-purpose communicative functions.

- the *Action Discussion* functions, which aim at bringing certain actions into the discussion that may or should be performed by the speaker, by the addressee, or jointly, and which are subdivided into *commissives*, where the speaker is (conditionally) committing himself to a certain action, and *directives*, where the speaker is putting pressure on the addressee to (conditionally) perform or participate in a certain action.

Table 4.1 shows the structure of the taxonomy of general-purpose functions and a number of functions that inhabit this structure. The complete set of functions can be found in Annex A.

Within the subcategory of questions various question types are distinguished, such as questions which enquire after the truth of a proposition ('propositional questions', often also called yes-no questions), questions which aim at identifying those elements of a given set which have a certain property ('set questions', often also called 'WH-questions' after the question words that are mostly used for expressing this type of questions in English), and questions which aim at discriminating between two ore more alternatives ('alternatives question', also known as 'multiple-choice question'). These three types of question occur in two variants in the taxonomy: a direct and an indirect version. The difference is that in the direct case the speaker expresses an assumption that the addressee knows the answer; in the indirect version no such assumption is expressed. This is one possible way of making a semantic distinction (which one may or may not want to make) between questions like *What time is it?* and *Where is Harry's office* on the hand, and questions like *Do you know what time it is?* and Can you tell me where Harry's office is? on the other.

The subcategory of information-providing function falls apart in those functions where the speaker is providing information in

Dimension	*Dimension-specific ommunicative functions*	*Typical expressions*
Task/Activity	OpenMeeting, CloseMeeting;	domain-specific fixed expressions
	Appoint, Hire, Fire	
Auto-Feedback	PerceptionNegative	*Huh?*
	EvaluationPositive	*True.*
	OverallPositive	*OK.*
Allo-Feedback	InterpretationNegative	*THIS Thursday.*
	EvaluationElicitation	*OK?*
Turn Management	TurnKeeping	final intonational rise
	TurnGrabbing	hold gesture with hand
	TurhGiving	*Yes.*
Time Management	Stalling	slowing down speech; fillers
Contact Management	ContactChecking	*Hello?*
Own Communication Management	SelfCorrection	*I mean...*
Partner Communication Management	PartnerCompletion	completion of partner utterance
Discourse Structure Management	DialogueActAnnouncement	*Question.*
	TopicShiftAnnouncement	*Something else.*
Social Obligations Management	Apology	*I'm sorry.*
	Greeting	*Hello!, Good morning.*
	Thanking	*Thanks.*

Table 3: Examples of dimension-specific communicative functions and typical expressions per dimension.

response to an information need that the addressee has signalled ('answers') and those where the motivation to provide information comes from the speaker: he wants the addressee to know or be aware of something, as in a teaching environment, or in the case of a warning ('informing functions'). Both the answering and the informing functions in a number of cases come in two varieties: a 'plain' one and an uncertain one. Especially for answers this is important: when asked a question, a respondent who is uncertain about the correctness or completeness of his answer will often indicate this, verbally and/or nonverbally, with correspondingly different effects on the information state of the addressee. Note that the subcategory of informing functions includes an open subclass of functions where the speaker's goal of informing the addressee of something is further specified in having a certain rhetorical, emotional, or evaluative function. This is one of several points where the DIT^{++} taxonomy has an open subclass.

The category of action-discussion functions corresponds essentially to the classes of commissives and directives from speech act theory; hence these names are used for the two subcategories of this category. Both the commissive and directive subcategories have open subclasses ot communicative functions, to accomodate the wide range of performative verbs that one may wish to distinguish at the semantic level of dialogue acts.

Many commissive and directive acts come in pairs, where one act brings an action into the discussion (proposing, or instructing, or promising,.. to perform that action), and another act is concerned with accepting or rejecting the performance of that action. If the first of these dialogue acts is a directive act, then the second is a commissive act, and vice versa. Different from other taxonomies and theories, the DIT^{++} taxonomy does not have separate functions like Accept Request and Decline Request, but a single function Address Request. The reason for this is that, apart from accepting and rejecting a request, a dialogue participant can also accept (or reject) a request conditionally, or with certain qualifications. (*I will do that only if you....*). This phenomenon occurs more generally for dialogue acts discussing actions, since actions can be done conditionally, repeatedly, with a certain intensity, and so on, and in general can be qualified in many ways, more than a proposition as the topic in information exchange acts. (See Bunt & Schiffrin, 2007, for more discussion on these and related issues.)

4.2 Dimensions

The ten dimensions of DIT^{++} have emerged from an effort to provide a semantics for dialogue utterances across a range of dialogue corpora. Utterances have been identified whose purpose was to address the following aspects of participating in a dialogue: (1) the performance of a task or activity motivating the dialogue; (2) the monitoring of contact and attention; (3) feedback on understanding and other aspects of processing dialogue utterances; (4) the allocation of the sender role; (5) the timing of contributing to the dialogue; (6) the structuring of the dialogue and the progression of topics; (7) the editing of one's own and one's partner's contributions; (8) the management of social obligations. Whether these aspects qualify as dimensions can be determined by checking the applying the above criteria (1).

Take for instance the timing of contributions. Utterances that address this aspect of interacting include those where the speaker wants to gain a little time in order to determine how to continue the dialogue; this function is called Stalling. Speakers indicate this function by slowing down in their speech and using fillers, as in *Ehm, well, you know,...* The observation that dialogue participants exhibit such behaviour means that the category of functions addressing the timing of contributions (which also includes the act of Pausing, realized by means of utterances like *Just a minute, Hold on a second*) satisfies criterion (1-1). Moreover, the devices used to indicate the Stalling function can be applied to virtually *any* kind of utterance, which may have have any other function in any other dimension. Timing therefore satisfies criterion (1-2) as well, and hence qualifies as a proper dimension.

A similar analysis can be applied to the other aspects. Of these, the feedback category (3) should be divided into two, depending on whether a speaker gives feedback on his own processing, or whether he gives or elicits feedback on the addressee's processing; we call these dimensions 'auto-feedback' and 'allo-feedback', respectively (cf. Bunt, 1995). Similarly, the category of dialogue acts concerned with editing one's own or one's partner's contributions, is better split into those concerned with editing one's own speech, called the Own Communication Management (OCM) di-

mension (using Allwood's terminology - see Allwood, 1997), and those concerned with the correction or completion of what the current speaker is saying, which by analogy we call the Partner Communication Management (PCM) dimension. See the examples of communicative functions within each of these dimensions, with common utterance forms in English, in table 4.1. Dialogue acts with a dimension-specific function are often performed partly or entirely nonverbally, such as positive feedback by nodding, negative feedback by frowning, or turn assignment by direction of gaze. A study by Petukhova (2005), preformed in the context of the EU project AMI (see footnote 4), showed that all the communicative functions of the nonverbal behaviour of participants in AMI meetings could be described adequately in terms of the DIT^{++} functions, and produced a catalogue of nonverbal means (notably head gestures, facial expressions, and gaze behaviour) for expressing DIT^{++} communicative functions, either by themselves or in combination with verbal behaviour.

All in all, this had lead to the following 10 dimensions in the DIT^{++} taxonomy:

1. Task/Activity: dialogue acts whose performance contributes to performing the task or activity underlying the dialogue
2. Auto-Feedback: dialogue acts that provide information about the speaker's processing (perception, interpretation, evaluation, or application) of the previous utterance or some particular previous utterance(s). Note that feedback is called 'positive' here if the processing at the level that is addressed, is or has been successful; negative feedback indicates a processing problem. Note also that 'evaluation' here means that the update information, which has been constructed by successful understanding of a diialogue segment, is evaluated and checked for not leadng to an inconsistent information state, or to an otherwise problematic situation. A positive evaluation leads to a process at the 'execution' level, where the participant's information state is indeed changed, and possibly further action is taken. For instance, the positive evaluation of a question leads to a decision to go ahead and try to answer the question; 'executing' a question means determining the answer to it. Similarly, evaluating an answer is deciding whether its content can be accepted without harm for the information state, and executing the answer is going ahead and integrate its content into the participant's information state. For signalling one's 'evaluation' of information in the sense of forming an *attitude* towards it, such as surprise or disappointment, an open subclass of functions has been added to the positive evaluation feedback function, similar to the open subclasses for informs with a rhetorical or attitudinal function.
3. Allo-Feedback: dialogue acts used by the speaker to express opinions about the addressee's processing (perception, interpretation, evaluation, or application) of the previous utterance or some particular previous utterance(s), or that solicit information about that processing;
4. *Contact Management*: dialogue acts for establishing and maintaining contact;
5. Turn Management: dialogue acts concerned with grabbing, keeping, giving, or accepting the sender role;
6. Time Management: dialogue acts signalling that the speaker needs a little time to formulate his contribution to the dialogue, or that his preparation for producing a contribution requires so much time that the interaction has to be suspended for a while (which may be due to various factors, such as something urgent intervening);
7. Discourse Structuring: dialogue acts for explicitly structuring the conversation, e.g. announcing the next dialogue act, or proposing a change of topic;
8. Own Communication Management: dialogue acts to indicate that the speaker is editing the contribution to the dialogue that he is currently producing;
9. Partner Communication Management: the agent who performs these dialogue acts has the addressee rather than the speaker role, and assists or corrects the dialogue partner in his formulation of a contribution to the dialogue;
10. Social Obligations Management: dialogue acts that take care of social conventions such as welcome greetings, apologies in case of mistakes or inability to help the dialogue partner, and farewell greetings.

5. USING DIT++

The DIT^{++} taxonomy has been and is being used for a variety of purposes:

1. for empirical and theoretical analysis and computational modelling of semantic and pragmatic phenomena in spoken and multimodal dialogue;
2. for annotating dialogues in order to build corpora with well-founded multidimensional annotation of communicative functions;
3. for designing components of dialogue systems, in particular for multimodal input interpretation, dialogue management, and the generation of multifunctional dialogue behaviour in spoken or multimodal dialogue systems;
4. as a well-defined comprehensive, general-purpose taxonomy that unifies and incorporates insights from a range of earlier efforts and projects, it has served as the starting point for an ISO effort to define interoperable concepts for dialogue act annotation.

In this section we briefly consider each of these uses of the DIT^{++} taxonomy.

5.1 Multimodal Dialogue Analysis

Information flow and grounding. Every communicative function in the DIT^{++} taxonomy is formally defined as a particular type of update operation on an addressee's information state. Information states, called 'contexts' in DIT, are viewed as being highly structured, with various components of a structured dialogue context corresponding to various aspects of interacting as reflected in the dimensions of the taxonomy. Depending on its dimension, a dialogue act updates a particular context component; a multifunctional utterance leads to the update of several components. This approach provides good instruments for studying and modelling the flow of information between the participants in a dialogue. Fine-grained models of information flow through the understanding of dialogue behaviour in terms of DIT^{++} dialogue acts have been developed and analysed in Morante (2007), and have resulted in a empirically-based computational model of *grounding* in dialogue (Bunt & Morante, 2007; Bunt et al., 2007).

Semantics of discourse markers. Another pragma-semantic study

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within	Task	Auto-F.	Allo-F.	Turn M.	Time M.	DS	Contact M.	OCM	PCM	SOM
Task		1.1 (1.2)	0.1 (2.7)	5.6 (8.5)	2.6(3.4)	0.3(0.3)	0(0)	4.3(4.6)	0.3(0.3)	1.5(1.5)
Auto-F.	0.5(0.7)		0(0)	12.7(15.5)	0.5(2.6)	0.3(3.1)	0(0)	0(0)	0(0)	0(0.5)
Allo-F.	0(3.3)	0(0)		23.7(23.7)	1.2(1.5)	0(0)	0(0)	0(15.4)	0(5.1)	0(0)
Turn M.	39.3(40.8)	6.2(12.2)	1.8(6.0)		49.6(60.6)	0.7(1.1)	0(0.3)	2.5(5.9)	0(0.7)	0.4(0.7)
Time M.	34.6(41.7)	0.5(3.5)	0(11.2)	9.1(9.7)		0(0.5)	0(0)	0(4.2)	0(1.4)	0(0.6)
DS	1.7(6.8)	0(6.8)	0(0)	6.7(20.9)	0(1.7)		0(0)	0(1.7)	0(0)	0(8.4)
Contact M.	0(0)	0(0)	0(0)	18.2(18.2)	0(0)	0(0)		0(0)	0(0)	0(0)
OCM	77.9(80.9)	0(0)	0(5.4)	6.5(6.5)	0(8.0)	0(0.9)	0(0)		0(0)	0(0)
PCM	0(0)	0(0)	0(18.2)	27.3 (27.3)	0(0)	0(0)	0(0)	0(0)		0(0)
SOM	0.9(0.9)	0(1.2)	0(0)	1.2(8.3)	0(1.2)	13.9(13.9)	0(0)	0(0)	0(0)	

*

Table 4: Co-occurrences of communicative functions across dimensions in AMI corpus expressed in relative frequency in %, with and without nonverbal behaviour taken into account (in brackets).

based on the multidimensional approach of the DIT^{++} taxonomy is that of the semantics of discourse markers; words or phrases that connect the pieces in a dialogue (or in a monologue), like *but*, *and*, *so*, *well*, etc. It was shown that such words often perform multiple semantic functions, which are well explained in terms of the dimensions and the view of multifunctionality represented in the DIT^{++} taxonomy (Petukhova & Bunt, 2009).

The meaning of nonverbal dialogue behaviour. Petukhova (2005) investigated the applicability of the DIT^{++} taxonomy to nonverbal behaviour in dialogues in the AMI corpus. It was found that the DIT^{++} functions provided fulll coverage for interpreting the nonverbal activity. The nonverbal behaviour may serves four purposes: (1) emphasizing or articulating the semantic content of dialogue acts; (2) emphasizing or supporting the communicative functions of the synchronous verbal behaviour; (3) performing separate dialogue acts in parallel to what was contributed by the partner (without turn shifting); or (4) expressing a separate communicative function in parallel to what the same speaker is expressing verbally. It was recently found (Petukhova 2009, p.c.) that the latter purpose occurs much less than the other three, as witnessed by the fact that the multifunctionality of dialogue segments taking nonverbal behaviour into account shows only a small increase compared to the case where nonverbal behaviour is not taken into consideration.

Multifunctionality and co-occurrence patterns. To generate multifunctional dialogue behaviour in a sensible way, it is important to have qualitative and quantitative knowledge of this phenomenon, and to know which kinds of multifunctional utterances occur in natural dialogue. Studies by Bunt (2007; 2009) and Petukhova (p.c.) have shown that, when a very fine-grained segmentation is applied to dialogue, with very small and possibly overlapping and interleaved functional segments as markables, the average multifunctionality of a markable in spoken dialogue without visual contact amounts to 3.7. With visual contact this is of course higher (and there is an increase of more than 25% of the total number of segments, mostly for participants not in the speaker role providing nonverbal feedback). Table 4.2 (from Petukhova, p.c. 2009) summarizes the co-occurrence data that were found for communicative functions in each pair of DIT^{++} dimensions, with and without taking nonverbal signals into account. (Based on data from the AMI corpus.)[2] Each row in the table describes the relative number of times that an utterance addressing the corresponding dimension, also addressed the dimensions corresponding with the columns. For the most frequently addressed dimensions (the top six rows of the table), the most important cases where nonverbal signals added multifunctionality ate the following:

Task: Auto- and Allo-Feedback, Turn Management, and OCM;
Auto-Feedback: Task, Turn Man., Contact Management, PCM;
Allo-Feedback: Task, Turn Man., Time;
Turn Management: Task, Auto- and Allo-Feedback, Time, Contact Man., OCM;
Time Management: Task, Auto-Feedback. Turn Man., OCM.
Discourse Structure Man.: Task, Auto- and Allo-Feedback, Turn Man.,Contact Man., SOM

The nonverbal signals taken into account here include gaze behaviour and head and hand movements; they do not include facial expressions, which is undoubtedly a rich further source of communicative functionality. It can be observed that the addition of nonverbal signals has an effect for all ten dimensions, the most important effects (in terms of frequency of occurrence) being that nonverbal signals are used for feedback, turn management, and own communication management. These figures also indicate clearly that multifunctionality across dimensions is a very real and important phenomenon in natural dialogue.

5.2 Annotation

The DIT^{++} taxonomy has been applied in manual annotation of dialogues from various corpora: the DIAMOND corpus of two-party instructional human-human Dutch dialogues (1,408 utterances); the AMI corpus of task-oriented human-human multi-party English dialogues (3,897 utterances); the OVIS corpus of task-oriented human-computer Dutch dialogues (3,942 utterances); TRAINS dialogues (in English); and Map Task dialogues both in English and in Dutch. Geertzen et al. (2008) report on the consistency with which naive annotators as well as expert annotators were able to perform annotation, and compares the results. Expert annotators achieve agreements scores of over 90%; naive annotators achieve scores in the order of 60%. .

The LIRICS taxonomy of communicative functions, which is a slightly simplified version of the DIT^{++} taxonomy, was tested in manual annotation of test suites in Dutch, English, and Italian, with very high consistency - see subsection 5.4 and table 5.4.

5.3 Dialogue system building

Dialogue management. The DIT^{++} taxonomy has been used in the design and implementation of the PARADIME dialogue manager, that forms part of the IMIX system for multimodal information extraction; see Keizer & Bunt (2006; 2007). The multidimensional dialogue manager generates sets of dialogue acts (in formal

[2] **A**ugmented **M**ulti-party **I**nteraction (`http://www.amiproject.org/`)

representation) that are appropriate in the current dialogue context, and delivers these to a module for expressing sets of dialogue acts in multifunctional utterances. This opens the opportunity to generate multifunctional utterances in a deliberate and controlled fashion.

Machine recognition of DIT++ functions. A prerequisite for using dialogue acts in a dialogue manager is that th dialogue system is able to recognize dialogue acts sufficiently well. The automatic recognition of dialogue in the DIT^{++} taxonomy (as well as in other taxonomies, such as DAMSL) was investigated for the corpora mentioned above, as well as for dialogues from the Monroe and MRDA corpora. For the various dimensions of the DIT^{++} taxonomy, F_1 scores were found ranging from 62.6 to 96.6%, without tweaking the feature use in the machine learning algorithms. This suggests that the recognition of (multiple) functions in the taxonomy is a realistic enterprise. For details see Geertzen (2009).

5.4 Towards a standard for functional dialogue markup

In 2008 the International Organization for Standards started up the project Semantic Annotation Framework, Part 2: Dialogue acts, which aims at developing an international standard for the markup of communicative functions in dialogue. This project builds on the results of an ISO study group on interoperability in linguistic annotation, of which the European project LIRICS[3] was a spin-off. In the LIRICS project, a taxonomy of communicative functions was defined by simplifying the DIT^{++} taxonomy a little, retaining its dimensions but eliminating the distinction of levels of feedback as well as the uncertain variants of information-providing functions and the informs with rhetorical functions, and excluding some of the low-frequency functions. The resulting LIRICS taxonomy has 23 general-purpose functions (where DIT^{++} has 34 plus 3 open classes) and 30 dimension-specific functions (where DIT^{++} has 55, of which 20 dine-grained feedback functions).

The LIRICS taxonomy was applied by three expert annotators to the LIRICS test suite dialogues in Dutch and English. Unusually high, near-perfect agreement was found between the annotators, as shown in table 5.4 (standard κ-values).

Function category	*Annotator agreement* (κ)
information-seeking	0.97
information-providing	0.98
action discussion	0.99
auto-feedback	0.99
allo-feedback	1.00
interaction management	0.94
social obligations management	0.94

Table 5: LIRICS annotation statistics

The ISO project takes the DIT^{++} and LIRICS taxonomies as point of departure for defining a comprehensive open standard for functional dialogue markup. For the current status of the project see ISO (2009).

6. CONCLUSIONS

In this paper we presented the DIT++ taxonomy of communicative functions. We indicated some of its theoretical background and its applications in human and machine annotation and dialogue management and generation. Co-occurence date for communicative functions, indicating the naturally occurring combinations of communicative functions, may be useful for deliberately generating multifunctional dialogue behaviour, which is especially important in multimodal contexts like those of embodied conversational agents, where facial expressions, gestures, and language together should be used to achieve natural forms of multifunctional behaviour.

[3] `http://lirics.loria.fr`

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8. ANNEX A. THE DIT^{++} TAXONOMY

The DIT^{++} taxonomy in its current version has been stable for the last two years. Occasionally, small improvements have been made in some of the definitions and guidelines. For the latest version see `http://dit.uvt.nl`.

As described above, the full set of communicative functions consists of (a) a taxonomy of general-purpose functions, and (b) one of dimension-specific functions.

General-purpose functions

The full set of general-purpose functions, displayed in Table 6, is a superset of the taxonomy in Table 2.

– *Information Transfer Functions*
  – *Information-Seeking Functions*
    – *Direct Questions*
      – propositional question
        – check question
          – posi-check
          – nega-check
      – set question
      – alternatives question
    – *Indirect Questions*
      – indirect propositional question
      – indirect set question
      – indirect alternatives question
  – *Information-Providing Functions:*
    – *Informing Functions:*
      – inform
        – agreement
        – disagreement
          – correction
        – *Informs with Rhetorical Functions, such as*
          – elaboration
          – justification
          – exemplification
          – . . .
        – *Informs with Attitudinal Functions, such as*
          – warning
          – threat
          – . . .
    – *Answer Functions:*
      – propositional answer
        – confirmation
        – disconfirmation
      – set answer
      – uncertain propositional answer
        – uncertain confirmation
        – uncertain disconfirmation
      – uncertan set answer
– *Action Discussion Functions*
  – *Commissives*
      – offer
        – promise
        – address request
          – accept request
          – decline request
        – address suggestion
          – accept suggestion
          – decline suggestion
      – *other commissives, expressable by means of performative verbs*
  – *Directives*
      – indirect request
        – (direct) request
      – instruct
        – address offer
          – accept offer
          – decline offer
      – suggestion
      – *other directives, such as* advice, proposal, permission, encouragement, urge,..., *expressable by means of performative verbs*

Table 6: DIT^{++} taxonomy of general-purpose communicative functions.

– *Dimension-Specific Communicative Functions*
  – *Task/Domain-Specific Functions*
    – *Functions, expressible either by means of performative verbs denoting actions*
    – *for performing tasks in a specific domain, or by means of nonverbal actions such as*
    – *highlighting, or pointing to something in a picture. For example:*
      – Open Meeting, Suspend Meeting, Resume Meeting, Close Meeting *(in meeting situations)*
      – Bet, Accep tBet, Reject Bet *(in betting situations)*
      – Congratulation, Condolance
      – Hire, Fire, Appoint,... *(in a human resource management domain)*
      – Show, Highlight, Point, List,... *(for performing graphical or multimodal dialogue acts)*
  – *Dialogue Control Functions*
    – *Feedback Functions*
      – *Auto-Feedback Functions*
        – Positive (= Unspecified Positive) Feedback
          – Attention Positive Feedback
            – Perception Positive Feedback
              – Interpretation Positive Feedback
                – Evaluation Positive Feedback
                  – Execution Positive (= Overall Positive) Feedback
        – Negative (= Unspecified Negative) Feedback
          – Execution Negative Feedback
            – Evaluation Negative Feedback
              – Interpretation Negative Feedback
                – Perception Negative Feedback
                  – Attenttion Negative (= Overall Negative) Feedback
      – *Allo-Feedback Functions*
        – *Allo-Feedback-Giving Functions*
          – Positive (= Unspecified Positive) Feedback
            – Perception Positive Feedback
              – Interpretation Positive Feedback
                – Evaluation Positive Feedback
                  – Execution Positive (= Overall Positive) Feedback
        – Negative (= Unspecified negative) Feedback
          – Evaluation Negative Feedback
            – Execution Negative Feedback
              – Interpretation Negative Feedback
                – Perception Negative Feedback
                  – Attention Negative Feedback
        – *Feedback Elicitation Functions*
          – Attention Feedback Elicitation
            – Perception Feedback Elicitation
              – Interpretation Feedback Elicitation
                – Evaluation Feedback Elicitation
                  – Execution Feedback Elicitation

Table 7: Dimension-specific communicative functions, part 1: functions for task performance and feedback.

Dimension-specific functions

The full set of dimension-specific functions is shown in tables 7 and 8, divided over two tables to enable the taxonomy to be represented on paper.) The reader is also referred to the website `http://dit.uvt.nl`, where the definitions of all the communicative functions can be found, plus guidelines for their use in annotation.

- *Interaction Management Functions*
  - *Turn Management Functions*
    - *Turn-unit-initial functions*
      - Turn Accept
      - Turn Grab
      - Turn Take
    - *Turn-unit-final functions*
      - Turn Assign
      - Turn Keep
      - Turn Release
  - *Time Management*
    - Stalling
    - Pausing
  - *Contact Management*
    - Contact Check
    - Contact Indication
  - *Own Communication Management*
    - Error signaling
      - Retraction
        - Self-correction
  - *Partner Communication Management*
    - Completion
    - Correct-misspeaking
  - *Discourse Structure Management*
    - Opening
    - Preclosing
    - Topic Introduction
    - Topic Change Announcement
      - Topic Shift
  - *Social Obligations Management*
    - *Salutation*
      - Initial greeting
      - Return greeting
    - *Self-introduction*
      - Initial self-introduction
      - Return self-introduction
    - *Apologizing*
      - Apology
      - Apology-downplay
    - *Gratitude Expression*
      - Thanking
      - Thanking-downplay
    - *Valediction*
      - Initial goodbye
      - Return goodbye

Table 8: Dimension-specific communicative functions, part 2: functions for Interaction Management and Social Obligations Management