STRATEGIES OF DIALOGUE

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The paper is focused on man machine dialogue (MMD) domain. The main contribution is about the formalization of the dialogue process beetwen an user and the machine, in terms of goals and strategies. Our approach is based on the beliefs, the goals and the acts and contains implicitly a deontic logic (as « social » obligations of the partners). By making the strategies of dialogue vary, we end up with relatively natural dialogues as shown as example. We have willingly considered that the MMD is a mechanism of handling of goals with a language component: it must connect a user with his task, with the assistance of the machine. Our model take place in the general framework of "game theory". It is thus through an operative and actional framework that we base our approach. This framework allows to give a more generic basis to the man machine interaction: one thus imagines rather easily that this model can adapt itself to any form of non language interaction. The paper presents essentially some features of a formulation of dialogue game theory that attempts to mirror and expand a theory of conversations proposed by Vanderveken in the context of illocutionary logic.

1. POSITION OF THE PROBLEM

The strategies of dialogue are ways to reach a goal through the dialogue seen as a joint activity [11]. Even if, at the start of a dialogue (more generally of a conversation), the speaker and the hearer do not have the same objectives, they share the intention to maintain the conversation and aim at a certain *conversational goal*. They may simply enter into dialogue from a phatic point of view (exchange of impressions, welcoming conversation), they may debate about their deep convictions or may negotiate a transaction. In all these cases, the dialogue takes place in a *framework* defined by the following elements:

(a) The conversational goal (or collective intentionality) which gives the finality of the conversation. One distinguishes according to Vanderveken [10]:
- the conversations around the state of things of the world (report, news, narrative descriptions, scientific debates, request for information, etc.),
- the commitment discourses or dialogues (decision-making, actions to carry out in common, propaganda, sermon, negotiation, etc.),
- the conversations with a double direction of fit (theorizing, verbal thought, work session, etc.),
- the discourses which express mental attitudes (prayer, lamentations, etc.) predominantly expressive,

(b) the sequence,
(c) the topic of the discourse and,
(d) the background of the conversation (situation, world of the task if there is one, social roles, etc.)

One must distinguish between the goal of the dialogue that is in the background from the conversational goal that is necessarily shared (if it is not, there is a misunderstanding about the type of dialogue). For example, the salary negotiation implies an initial goal (request for a raise) and a conversational goal which is to lead to a negotiation within the social and cultural rules of the profession. Thus, the conversational goal can be satisfied while the initial goal may not necessarily be.

In a particular framework, for (a), (c) and (d) given, the sequence will depend on the strategies used by the speakers in order to satisfy the conversational goal. Reciprocally, and in a reflexive manner, it is the sequence structure that will constrain the strategy that the speakers will be able to use. Let us define this more precisely.

1.1. DEFINITIONS

We suppose that there are two speakers who enter into dialogue and that at the start each one aims at a certain goal in the background. We will note L for speaker and A for hearer (in the case of the MMD, man-machine dialogue, we will note U for user and M for machine). Their goals will be noted, b_L and b_A, one of them possibly being empty.

Let us define:

Initial goal: The state of the world or the mental state that one of the two speakers wants to reach, either for himself (to obtain an information, acquire a know-how, etc.), or for his partner (give him an information, make him do something, give him a piece of advice, etc.).

Exchange: a series of talking turns during which a goal is sustained. The start of an exchange is marked by the emergence of a new goal, this goal is possibly transformed during the exchange (it can become keener for example or decompose itself into sub-goals) and becomes an irreducible final goal on which the exchange ends by a success or by a failure. The success obeys to the double condition of being a *goal reached* and a *goal satisfied* [7], [9]. As for the exchange, it develops itself on two axis: the governing axis and the incident axis [5].

Goal of the exchange: that which is sustained during the exchange.
Final goal: the state of the world or of the situation at the end of an exchange (it always ends, at least by the agreement of the two speakers about the fact that there is failure when there is failure: "the trade unions and the employers have parted on an acknowledgement of failure"). The final goal is not always predictable at the start.

Incidence: a speech act that has for effect to put a goal on hold or in question (through a change of topic, a request for clarification, a request for further details, etc.), but which does not call into question the conversational goal of the exchange. The dialogue continues generally on this incident axis before coming back on the axis governing the exchange. There can be several levels of incidence.

Strategy of dialogue: the way to handle the talking turns between speakers to lead an exchange or an incidence. The strategy aims at choosing the best direction of fit of the goals at a given moment.

Direction of fit: there are 5 possible directions of fit of the goals that lead to 5 types of strategy:

- A abandons his goal in favour of that of L (reactive strategy), in other words A fits his goal on that of L (in abbreviated form $b_A \rightarrow b_L$)
- A imposes his goal to the detriment of that of L (directive strategy), in other words he forces L to adopt his goal (in abbreviated form $b_A \leftarrow b_L$)
- A and L each keep their goal (strategy of negotiation), in other words they do no try to fit their goals *a priori* (in abbreviated form $b_A \leftarrow b' \rightarrow b_L$) even if at the end of the negotiation a compromise b' is found
- A and L take positively into account the goal of the other (strategy of cooperation), in other words they try to fit one to the other (in abbreviated form $b_A \leftrightarrow b_L$)
- A and L abandon their goals for a third one (constructive strategy), in other words they make a constructive detour (in abbreviated form $b_A \rightarrow b' \leftarrow b_L$)

Effectiveness of the strategy: a strategy is effective if the convergence speed of the speech acts towards the final goal is optimum. The criterion of effectiveness inferred from it is to reduce at the maximum at each

speech turn the distance to the final goal (however there can be local gaps to avoid reaching deadlocks or provoking failures).

Depth of an exchange: the number of talking turns within an exchange between the current talking turn and the start of the exchange.

1.2. TYPOLOGY OF THE STRATEGIES

Let us agree on the following notations:
b_L: initial goal of speaker L,
b_A: initial goal of hearer A,
b_f: final goal of the exchange,
b_c: conversational goal, supposed to be shared by A and L.
One can then define the following types of strategies (one places oneself in the string, from the point of view of the hearer A:

Non-inferential strategies
These strategies are called non-inferential to the extent where the one who carries them out does not try to find a joint goal with his partner and thus does not have to necessarily infer his goal.

1. Reactive strategy
Consists in delegating the initiative to L either by making him shoulder his goal (case of a request for help or assistance), or by adopting his goal (case of the servant). The sequence of the dialogue is done:

- by maintaining the goal of the exchange, but without taking an initiative,
- by abandoning one's own goal or by making it pass under the dependence of b_A.

A is passive and L is active. This has the effect of opening any type of strategy to one's interlocutor L.
The direction of fit is then $b_A \rightarrow b_L$

2. Directive strategy
Consists in keeping the initiative to lead the dialogue:

- by maintaining the goal of the exchange and by keeping the initiative,
- by imposing one's goal b_A, (thus one tries for $b_f=b_A$)
- by ignoring possibly that of the speaker b_L, who is thus in a way considered as nonexistent.

This has for consequence to impose a reactive or negotiated answer to L and to thus limit the variety of his strategies. A is active and L becomes passive. The direction of fit is then $b_A \leftarrow b_L$

3. Constructive strategy (or detour strategy)
Consists in momentarily shifting the current goal in order to provoke a detour (supposed to be constructive) which is not necessarily an incidence, for example to point out an omission, an error, make a quotation, recall an old fact, an experience, etc.:
The current goal is put on hold, as well as the initial goals, a new goal b' is posed, the initiative can be shared.
The direction of fit is then $b_A \rightarrow b' \leftarrow b_L$. Contrary to an incidence, a detour does not necessarily lead back to the initial exchange, it can leave the conversation unresolved or lead to another detour[1].

Inferential strategies
These strategies are said to be inferential to the extent that they require from the part of the two partners a perceptive knowledge of their respective goals. In these strategies the two speakers have a shared initiative.

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[1] This form of dialogue was widely used in ancient China.

4. Strategy of cooperation

Consists in taking into account the goal of one's speaker by proposing to him one (or several) solution(s) which lead them both to reach their goals, if the latter are not incompatible:

this leads to proceed according to a complex process – assess the situation, present an explanation, possibly some examples, some assistance or relevant arguments and to offer a closed choice (because it is more easy from a cognitive point of view for the decision taking), by maximizing the concession space, by going about things through the search for an optimum in a space of possible, by accompanying the speaker up to the solution, by widening the conversational goal if necessary,

This has the effect of opening any type of strategy to one's speaker. The direction of fit is then $b_A \leftrightarrow b_L$

5. Strategy of negotiation

The negotiation can occur in a situation where the goals are incompatible and when the speakers want to minimize the concessions. The negotiation is carried out on a rather classical pattern, through argumentative sequences (argumentation/ refutation) with a proposal of a sub-optimal solution up to the convergence or acknowledgement of failure. The local tactic is to:

- try to impose one's goal or to accept a compromise,
- maintain the conversational goal,
- pursue the negotiation as far as possible up to an acceptable goal b_f,

This has the effect of maintaining one's speaker in this strategy. The direction of fit is then $b_A \leftarrow b_f \rightarrow b_L$

Strategies	**Non-**	**Inferential**		**Inferential**	
Properties	**Reactive**	**Directive**	**Constructive**	**Negotiation**	**Cooperation**
Initiative	L	A	joint	joint	joint
Fit	b_L	b_A	other	no	reciprocal
Conversational goal	maintaining	maintaining	detour	maintaining	joint
Concession	max.	min.	without object	min.	max.
Role A	passive	active	neuter	active	active

2. GOALS

Conversational goal

Let us suppose that the conversational goal is given, it establishes the framework of the dialogue (in the dialogue man-machine it results from the type of task considered, for example a request for information).

Goal of the exchange

One generally defines a *goal* by a predicate. A goal is either a situation to reach in the world (situation or background), or a mental state to satisfy. For example:

$b = (x, y) : \text{circle}(x) \wedge \text{square}(y) \wedge \text{red}(x) \wedge (\text{on}(x, y))$

which means that the goal to reach is to obtain "a red circle on a square". This describes a state of the world (one can imagine for that purpose that L is in front of a computer screen and wants to draw a circle).

$b_L = (x) : \text{circle}(x) \wedge C_A(\text{ball}(x))$

which describes a goal that L tries to reach by acting on the mental state of the hearer A "teach to A that one of the circles represents a ball". According to the framework of the dialogue, L tries to convince A or to teach him something.

Let us note:

a new goal: ?b, this goal has just been expressed, it is said «posed»

a goal reached:	†b, the predicate b becomes true,
a goal satisfied:	‡b, the speakers demonstrate their agreement on †b, this agreement can be explicit or implicit (a knowing silence or the continuation of the dialogue without reappraisal). In general a goal is satisfied only by the person who has posed it.
a goal put on hold:	-b, one solves temporarily another problem,
a goal repaired:	b', further to a lack of understanding the goal is modified, one does not come back on the previous goal
a goal shifted:	b', further to a negotiation the goal is modified, but one can come back on the previous goal
a sub-goal:	sb, the problem is decomposed into sub-problems,
a goal abandoned:	@b, further to a failure or to a voluntary abandon

At the end of an exchange one has b_f= ‡b or b_f= @b, i.e. success or failure.

Handling of the goals during the exchange

The handling of the goals comes under the general paradigm of planning. One must make a distinction between:

- the planning of the task, which consists in solving a problem with the help of operators by disposing of elementary actions,
- the planning of the dialogue, which consists in organizing the talking turns according to the strategy to solve an exchange.

The planning of the task as such is not the subject of this book although the planning of the dialogue (a) uses comparable techniques, and (b) is not independent from the planning of the task, since the topic of the dialogue concerns the elements of the task, and that the function of the dialogue is to make the task progress above all in MMD.

The distinction between the task (which applies to the activity) and the dialogue (the activity as such) must be very clear. Thus a speech act, during a talking turn, can fully succeed although the task does not progress, for example:

L: hallo, I would like to speak to Mr Dupont

A: sorry, Mr Dupont is on holiday, call him back when he comes back

L: all right… thank you, goodbye

In this case it is clear that the dialogue proceeded perfectly well, that the goals of the dialogue and of the conversation have succeeded, that the dialogue has been effective, that L has received an information, that the conversational goal was well-shared, but nevertheless that L has not been able to speak to Mr Dupont, which was yet his goal.

This leads us so to make a clear distinction between the goal of the exchange and the illocutionary goal that we define now.

Speech act

One defines for each speech act, its illocutionary force expressed with the help of Searle and Vanderveken [8] typologies. It is useful to retain for the man-machine dialogue the following illocutionary forces [2]:

Act	Meaning	Searle equivalent
F^A	do or carry out an action (in verbal or non verbal)	declarative
F^F	(make do) ask the hearer to carry out an action	directive
F^S	(make known) communicate an information	assertive or expressive
F^{FS}	(do make-known) ask for an information	directive
F^P	(do can) give a choice, make an invite	promissive with delegation

F^D	(do must) oblige without giving an alternative	directive

This table gives the illocutionary force of the act but does not specify the way nor the shape of the statement: there can be many ways to ask for an information (by yes/no, in a closed list, with explanation, etc.), as for example:

« Will you come tomorrow? »

« What is your name? »

« Can you tell me where is the museum? »

Some questions may be make-do like:

« Have you got seats? »

The signs of welcome are make-can like "good morning" which shows in MMD the availability of the machine.

3. MODELLING OF THE MAN–MACHINE DIALOGUE

The objective of this paragraph is to pose the principles of a modelling of the man-machine dialogue (MMD) by using a logic of the action. One supposes that, like in a situation of human interaction, the speakers in a one-to-one debate (user and machine) build their dialogue in a rational way – that is to say around coordinated actions – while respecting normalized social conventions with a view to satisfy a goal. One supposes that the dialogue is both constructive (it goes through the construction of the goal from the objectives of the actors and is based on the mutual knowledge) and co-interactive (the actors coordinate their actions and their strategies to satisfy the goal). At each moment, the model makes the hypothesis that the dialogue is directed by the mental states (goals, intentions) of the user and by attitudes which underlie the acts (choices, commitments). Thus a "good model" of dialogue must allow the machine to presuppose the mental states of its speaker (which does not mean that the latter actually has these mental states) and to react according to rules of social type.

The general approach is based on a double rationality of the actions. One supposes that the conversants act rationally with regard to the goals they pursue, but also socially: they respect the social conventions through the role that they play. In the framework of the human dialogue, one can find this theory rather restrictive: in fact, it does not leave room for the unexpected or for the lie as strategy and places, implicitly, the desires under the control of rationality. But in the MMD, this reduction can be interesting to the extent that it assigns a place to the action and to the social rules in a pseudo-natural dialogue.

The logic of dialogue exposed hereafter aims at formalizing rules for *in fine* make it possible for a *controller of dialogue* to handle the acts of the human speaker (called hereafter *user*) reflecting his supposed mental states. This modelling does not aim at giving to the machine a behaviour of a human kind but only at supplying to it logical elements of choice and reasons to act. One does not try to give "artificial mental states" to the machine but to model the reasons for action of the speaker (even if afterwards one formalizes the acts of the machine with the same predicates as that of the human with a view to homogeneity of notation).

The dialogue is at the level of the coordination of the acts of user U and of the machine M. These acts modify the situation, i.e. make it pass at a given moment from $\xi(t)$to $\xi(t+1)$. One supposes that U is involved in a task, i.e. that he must reach a certain goal b. One supposes that this goal motivates the dialogue.

3.1. REPRESENTATION OF THE KNOWLEDGE: BELIEF.

We note all the knowledge by Bp, where p is a predicate. This notation is a way to represent the supposed knowledge of the machine about what the user might know, regarding p, which prejudges nothing about the actual truth of p, (B_Up does not imply p), nor if really U knows something about p. For the sake of convenience Bp could be read "believe p" and B_Up will be read "U believes p". With a view to symmetry and homogeneity of notation, the knowledge represented in the machine will be noted B_Mp. This notation does not mean that the machine "believes p" but that p is true "in the machine". Another way to represent the

interaction to oneself is to imagine that the user enters into dialogue with the designer of the machine and that the latter is only the reflection of the knowledge that the designer has implemented.

Axioms

Let us repeat once more that the aim is to establish here not a logic centred around the user but a model of representation in the machine of the supposed knowledge of the user (it is like as if one took the place of the designer who has in front of him a user with whom he wants both to enter into dialogue and analyze his own reactions). One is thus entitled to suppose that U is consistent even if in reality he not always is.

• consistency of the supposed knowledge of U:

One models the supposed fact that:

$B_U(p \wedge q) \supset B_U p \wedge B_U q$	
$B_U p \wedge B_U(p \supset q) \supset B_U q$	U believes in the consequences of his beliefs,
$B_U p \supset \neg B_U(\neg p)$	U does not believe the contrary of what he believes,
$B_U p \supset B_U(B_U p)$	U believes his own beliefs,
$\neg B_U p \supset B_U(\neg B_U p)$	U believes that he does not believe what he does not believe.

• consistency of the knowledge of M:

$B_M p \supset p$	M has no true belief
$B_M(p \wedge q) \supset B_M p \wedge B_M q$	
$B_M p \wedge B_M(p \supset q)) \supset B_M q$	means that $(p \wedge (p \supset q)) \supset q$
$B_M p \supset \neg B_M(\neg p)$	if p is represented in M, $\neg p$ is not,
$B_M p \supset B_M(B_M p)$	M knows if p exists in its knowledge base,
$\neg B_M p \supset B_M(\neg B_M p)$	M knows if a knowledge is not in its base

• consistency of the shared knowledge:

$B_M(B_U p) \equiv B_U p$	by definition
$B_U(B_M p) \not\equiv B_U p$	because for M, $B_M p \supset p$
$B_M p \wedge B_U(p \wedge q) \supset B_M p$	the supposed knowledge of U is not shared by M

• mutual sincerity of U and M:

One supposes that the conditions of sincerity are always true in MMD finalized. This leads to:

$F^S_M p \supset B_M p$	if M states p (noted $F^S p$) then M believes p, and consequently U is supposed to know it too,
$F^S_M p \supset B_U p$	because U trusts M (it practically means that it will be necessary to conceive a good interface which makes p clearly perceptible to U).
$F^S_U p \supset B_U p$	reciprocity for U
$F^S_U p \supset B_M p$	M modifies its knowledge according to the statements of U even if previously $B_M(\neg p)$ (the knowledge of M is non-monotone).

3.2. GOALS AND ACTIONS

It is the goals that motivate U into continuing the dialogue to fulfil the task that he has to do with the machine. However the machine can also pose goals to solve without necessarily having underlying intentions: in this case, it is only about a decomposition of the problem of dialogue into sub-goals.

Axioms

• Attitudes of U in front of his goals

The machine models the fact that:

$F^S_U b \wedge \neg b \supset ?b$	U states a new goal by showing it

$F^S_U b2 \wedge b1 \supset$-b1 $\wedge ?b2$	if U shows a second goal b2 while another goal b1 is already underway, one puts the latter on hold (because one deals with the dialogue on one thread only, i.e. exchange by exchange)
$\ddagger b \wedge F^S_U b \supset @b$	U has no reason to sustain a satisfied goal
$\dagger b \wedge \neg F^S_U b \supset \ddagger b$	if a goal is reached and that U does not question it, it is satisfied implicitly
$\dagger b \wedge F^S_U (\neg b) \supset @b$	if a goal is reached and that U questions it, one abandons it
$F^S_U (@b) \supset @b$	U can decide to abandon a goal deliberately

• Attitudes of U in front of the machine

The machine supposes that:

$b \supset F_U p$	the acts a of U are motivated by the current goal
$\neg F_U p$	the non-action is an hesitation or an incomprehension
$F^S_M b \wedge \neg b \supset ?b$	if it states a goal, it is accepted by U
$F^P_M b \supset F^S_U b$	if it gives a choice to U about the goals, the latter makes it
$F^D_M b \supset F^A_U b$	if it gives an obligation to U about the goal, the latter makes it

3.3. ACTIONS IN THE BACKGROUND

The actions in the background are either elementary actions or sequences of elementary actions for the task. In both cases, we will continue to call them *Plan*. Even if this plan is executed over a non-empty duration, we consider that its effect is immediate and that it changes the value of the predicate p_ξ which describes the situation $\xi(t)$. An only speech act can trigger a whole plan through its propositional content p. We will note this by p▪Plan. The speech acts are reflected in the background as follows:

$F^A p$: to carry out an action, the immediate effects obtained are p

$F^F p$: request to make p, the expected effects p are postponed until after the execution of the Plan triggered

$F^S p$: make known p, the effects are obtained immediately ($F^S(\emptyset)$ notes an expressive that has no effect on the task)

$F^{FS} p$: request on p, the answer expected is postponed until after the execution of the plan triggered

$F^P p$: offers a closed choice the answer is expected among p

$F^D p$: constrains an action the effect of which will be p after the execution of the Plan triggered

A speech act is borne by an oral statement α. This statement is supposed to be analyzed in view of its semantic and pragmatic decoding (problem not tackled in this paper). To understand what follows we however pose:

• incomplete(p) = $(\exists\alpha) \wedge$ attribute(α,p) $\wedge \alpha = \emptyset$) the propositional content p of the act Fp is incompletely specified by the statement α (certain attributes are empty)

• non-empty (p) = $(\exists\alpha) \wedge$attribute(α,p) $\wedge$.(α ¬= Ø) the propositional content p of the act Fp is non-empty

• complete (p) = $(\forall\alpha) \wedge$attribute(α,p) $\wedge$.(α ¬= Ø) the propositional content p of the act Fp is completely specified by the statement α

At this point we can state a few principles concerning the actions, for a logic of the action in the dialogue.

• the effects of the actions

$F^A xp \supset Byp$	the effects of an act are supposed to be taken into account by the hearer who has the means to observe them

• the reciprocal expectations between the partners x and y

$F^{FF} xp \supset F^A yp \vee F^{FS} yp$	the act expected is a contribution to the order received
$F^P xp \vee F^D xp \supset F^A yp \vee F^{FF} yp$	the act expected is a choice of action among those proposed

$F^{S}_{x}p \supset B_{y}p \vee F^{FS}_{y}p$ an information given is taken into account or clarified

$F^{FS}_{x}p \supset F^{S}_{y}p \vee F^{FS}_{y}p$ a question motivates the answer or a request for clarification

• the training

The training is a phase of dialogue during which the machine learns the sequence of actions that it does not know how to perform to reach a goal. This phase is triggered when:

$\neg F_{M}Plan \wedge b \supset ?b' \wedge F^{FS}_{M}b'$ M does not know how to solve goal b (for example it does not know the plan to do it), it shifts it into a goal to learn

From there on there are two phases of processing, the observation of the actions of U and a construction of the Plan.

Start- training: ?b' in the situation $\xi(t)$

AsLongAs $\neg F^{S}_{U}(\dagger b')$

do F_{U}(Plan)

EndAsLongAs

End- training: ‡b' in the situation $\xi(t+1)$

one infers $b'=\{\xi(t+1) \cap \xi(t))$

3.4. THE HANDLING OF STRATEGIES

The model of dialogue defined hereafter allows to handle the sequence of the acts of dialogue according to rules depending on the strategies.

Computation of the relevant strategy and of the behaviours

The computation of a strategy δ is done with the help of rules which take into account the completeness of an act of dialogue (if it is incomplete, one should may be try to complete it by asking an adequate question before acting), the possibility to reach a goal, the conditions of success of the act (is the situation favourable?), the state of the dialogue (is another goal on hold?), the expectations of the user (what goal is he pursing?), his competence (he is an expert or not?), the strategy previously adopted (it might not be wise to change strategy too often in order not to lead the user astray), etc. We give hereafter some ideas of possible computation of strategies, on the one hand a trigger rule at the most appropriate moment (or supposed to be), and on the other hand, the logic of sequence of the talking turns for all the possible situations.

Reactive dialogue

Triggering rule: the strategy becomes reactive if the number of talking turns π since the previous action of type $F^{\tilde{A}}$ exceeds a certain threshold. This mode is also activated in case of choice by the user or to close the dialogue.

$(\pi > \pi_{0}) \vee F^{S}_{U}(\delta_{reactive}) \vee F^{S}_{U}(closing) \supset \delta_{reactive}$

Behaviour: The conditions of completeness, of truth and of success are supposed to be verified since one does not question the requests of the user who accepts them. In case of incompleteness of the propositional content p however, one completes it by default, by considering the profile and the preferences of the user. This procedure is not explained here. The rules of behaviour of the machine to develop for this strategy are exclusively those for which U has the initiative (by definition M never has the initiative for this strategy), that is:

$F^{A}_{U}p \supset B_{M}p$ U carries out an act, M records the effects, by supposing that these effects are observable for M

$F^{F}_{U}p \wedge Cond^{F}(p) \supset F^{A}_{M}p \wedge B_{M}p$ U asks for an act to be carried out, M does it and records the effects on the condition that the act is f*easible*

$Incomplete(p) \supset Complete(p)$ I f p incomplete M completes by default

$Complete_{M}(p) \wedge p \blacksquare Plan \supset Cond^{F}(p)$ the act requested must be able to trigger a Plan

$F^{S}_{U}p \wedge$ Non-empty (p) $\supset B_{M}p$	U gives an information, M records it if at least it is not empty
$F^{FS}_{U}p \wedge B_{M}p \supset F^{S}_{M}p$	U asks a question, M answers it if it knows the answer
$F^{P}_{U}p \vee F^{D}_{U}p \supset F^{A}_{M}p \wedge B_{M}p$	M makes the proposed choice

Directive dialogue

Triggering rule: the strategy is directive at the start of the dialogue (presentation phase) and in a situation of error, of incomprehension or of deadlock. This mode is also activated in case of choice of the user.

$(\pi = 0) \vee F^{S}_{U}(\delta_{directive}) \vee F^{S}_{M}(error) \supset \delta_{directive}$

Behaviour: The conditions of completeness, of truth and of success are supposed to be verified since the machine keeps the initiative and only asks for acts in the order of the possible. In case of incompleteness of the propositional content p, one completes it however by default, by considering the profile and the preferences of the user. This procedure is not explained here. The rules of behaviour of the machine to develop for this strategy are exclusively those for which M has the initiative (by definition U never has the initiative for this strategy), that is:

$F^{A}_{M}p \supset B_{M}p \wedge B_{U}p$	M carries out an act and records the effects, and supposes that these effects are observable for U
$F^{F}_{M}p \vee F^{D}_{M}p \supset F^{A}_{U}p \vee F^{s}_{U}q$	M makes do a *feasible* act to U who is supposed to do it or who can refuse to do it
$F^{A}_{U}p \supset B_{M}p$	M records the effects if U actually carries out the action
$F^{s}_{U}q \supset \delta_{negotiation}$	if U questions, one changes the strategy
$F^{S}_{M}p \supset B_{U}p$	M gives an information that is supposed to be taken into account by U
$F^{FS}_{M}p \wedge B_{U}p \supset F^{S}_{U}p$	M asks a question, U answers it if he knows the answer
$F^{s}_{U}p \wedge$ non-empty (p) $\supset B_{M}p$	M takes into account the answer if it is non-empty
$F^{FS}_{M}p \wedge \neg B_{U}p \supset F^{FS}_{U}q$	M asks a question, U asks a question of clarification or questions it if he does not know the answer
$F^{s}_{U}q \supset \delta_{negotiation}$	one changes the strategy because in the two cases of request for clarification or of contestation, the directive strategy is no longer adapted
$F^{P}_{M}p \supset F^{s}_{U}p \wedge B_{M}p$	U makes the proposed choice

Constructive dialogue

Triggering rule: The constructive strategy is mostly used to alert the user or to attract his attention on goals related to his purpose. It can be used if he seems « to have come to a standstill ». It can finally be used as a way of detour. It remains at the initiative of the machine.

$F^{S}_{M}b' \vee F^{P}_{M}p \vee \neg F_{U} \supset \delta_{constructive}$

Behaviour: The conditions of completeness, of truth and of success are supposed to be verified, since the machine keeps the initiative and only makes suggestions in the order of the possible. The behaviour rules of the machine to develop for this strategy are exclusively those for which M has the initiative (by definition U does not have the initiative for this strategy), that is:

$F^{S}_{M}p \supset B_{U}p$	M gives an information that is supposed to be taken into account by U
$F^{FS}_{M}p \wedge B_{U}p \supset F^{S}_{U}p$	M asks a question, U answers it if he knows the answer

$F^{s}_{U}p \wedge$ non-empty $(p) \supset B_{M}p$	M takes the answer into account if it is non-empty
$F^{FS}_{M}p \wedge \neg B_{U}p \supset F^{S}_{U}\neg p$	M asks a question, U refutes the contents of the question
$F^{s}_{U}\neg p \supset \delta_{cooperation}$	one changes the strategy because the constructive strategy is no longer adapted
$F^{P}_{M}p \supset F^{s}_{U}p \wedge B_{M}p$	U makes the suggested choice

Dialogue of negotiation

Triggering rule: the strategy of negotiation is interesting when a line of argument proves to be useful to make the dialogue or the task progress. In a finalized dialogue, it is however preferable not to use it excessively because it slows down the activity. This strategy is useful in the case when the propositional content of a user's act is incomplete.

$(\pi < \pi_0) \wedge F_{U}p \wedge$ incomplete $(p)) \supset \delta_{negotiation}$

Behaviour: The conditions of completeness, of truth and of success must be verified. The initiative is shared during the negotiation. The classical sequence of a negotiation is: (a) X makes an argued offer, (b) Y accepts it or makes a counter-offer by denying the arguments of X, or makes a compromise by accepting part of the arguments of X and by denying the others, (c) and so on until the resolution of the problem, with at the exit of the process a positive result (success of a compromise) or negative (failure). In the dialogue man–machine the resistance of the machine must be revised downwards, it is not about standing up to a user in a persistent manner. One will thus content oneself with a negotiation at one turn, that is to say: if refusal by U, then acceptance of his solution. One thus only places oneself in the case where the machine proposes a negotiation at one turn. That is:

$F_{U}p \wedge$ incomplete$(p) \supset F^{S}_{M}p \wedge F^{S}_{M}q$ from the acknowledgement of a p incomplete, M explains p and argues on q so that incomplete$(p) \supset$ complete$(p \wedge q)$

$F^{FS}_{U}q \supset F^{S}_{M}q \wedge B_{U}q$ U can then ask a question of clarification, M answers it since it is supposed to know the answer

$F^{s}_{U}q \supset B_{M}q \wedge$ Success U can accept q, since there is success

$F^{s}_{U}q' \wedge$ non-empty $(q') \wedge \neg B_{M}(\neg q') \supset B_{M}q' \wedge$ Success U can make another proposition q', since there is success. M accepts this proposal and M takes into account the answer if it is non-empty and not contradictory to its knowledge.

$B_{M}(\neg q') \supset F^{S}_{M}q' \wedge B_{M}q' \wedge$ Success M accepts the knowledge even if they are contradictory to its own but notifies it to U

$F^{s}_{U}\neg q \supset B_{M}\neg q \wedge \neg$Success U can refuse q, when there is failure

Success $\supset \delta_{reactive}$ One shifts to a reactive strategy to answer to the initial act $F_{U}p$ completed by q or q'

$\neg$Success $\supset \delta_{cooperative}$ One shifts to a cooperative strategy

Dialogue of cooperation

Triggering rule: the level of assistance expected is different according to the level of competence of the user. To simplify, we develop two variants of cooperation forms depending on whether the user is an *expert* or a *novice*. If he is an expert, we suppose that he is explicitly asking for assistance. If he is a novice, one triggers this strategy as basic strategy or in case of inaction.

Expert case: $F^{S}_{U}(\delta_{cooperative}) \wedge B_{M}(U,$ expert$) \supset \delta^{1}_{cooperative}$

Novice case: $F^{S}_{U}(\delta_{cooperative}) \vee B_{M}(U, \neg$expert$) \vee \neg F^{A}_{U}p \supset \delta^{2}_{cooperative}$

Behaviour: The behaviour of M will be different in the two cases: in the first case, the expert looks for a maximum of efficiency, he knows the system and wishes to be assisted in the resolution of the goals or even in a anticipated and reactive manner. In the second case, the novice asks for more explanations about the process, for constant help and in fact for a pedagogic behaviour, i.e. quite directive with explanations. In

these conditions, the first strategy of cooperation is close to a reactive strategy and the second is close to a directive strategy. That is:

Expert Case

$F^{FS}_M b \wedge B_U b \supset F^{S}_U b \wedge F^{A}_M(b \blacksquare Plan)$	M proposes to U to anticipate a goal b and carries out the corresponding plan if U accepts
$F^{FS}_M b \wedge B_U b \supset F^{S}_U \neg b \wedge F^{p}_M(b')$	if U does not accept M proposes another goal
$F^{s}_U b' \wedge complete_M(b') \supset B_M b' \wedge F^{A}_M(b \blacksquare Plan)$	if this new goal is accepted then M tries to carry it out by completing it by default if necessary

$incomplete_U(b') \supset complete_M(b')$

$\neg F^{s}_U b' \supset B_M \neg b' \wedge \delta_{reactive}$

All the other behaviours are identical to those of the reactive strategy

Novice case

When M has the initiative, it comments its acts more than in a pure directive strategy

$F^{A}_M p \wedge F^{S}_M b \supset B_M p \wedge B_U p$	M carries out an act and records its effects, supposes that these effects are observable for U and comments the goal pursued
$(F^{F}_M p \vee F^{D}_M p) \wedge F^{S}_M b \supset F^{A}_U p \vee F^{FS}_U p$	M makes do a *feasible* act to U who is supposed to do it or who can request some explanations to do it
$F^{A}_U p \supset B_M p \wedge F^{S}_M b$	M records its effects if U actually carries out the action and comments the effects
$F^{FS}_U p \supset F^{S}_M p$	if U asks for help M gives it to him
$F^{S}_M p \wedge F^{S}_M b \supset B_U p \wedge F^{FS}_M p$	M gives an information which is supposed to be taken into account by U and asks him to give a confirmation
$F^{FS}_M p \wedge B_U p \wedge F^{S}_M b \supset F^{S}_U p$	M asks a question, U answers it if he knows the answer
$F^{s}_U p \wedge non\text{-}empty(p) \supset B_M p$	M takes the answer into account if it is non-empty
$F^{FS}_M p \wedge \neg B_U p \supset F^{FS}_U q$	M asks a question, U asks a question of clarification or questions it if he does not know the answer
$F^{s}_U q \supset \delta_{negotiation}$	one changes the strategy because in the two cases of request for clarification or of contestation, the cooperative strategy is no longer adapted
$F^{P}_M p \wedge F^{S}_M b \supset F^{s}_U p \wedge B_M p$	U makes the proposed choice

When U has the initiative the cooperative strategy consists in helping the understanding of M answers. It is thus of a reactive kind with explanations.

$F^{A}_U p \supset B_M p \wedge F^{S}_M p$	U carries out an act, M records its effects (supposing that these effects are observable for M) and comments them
$F^{F}_U p \wedge Cond^{F}(p) \supset F^{A}_M p \wedge B_M p \wedge F^{S}_M p$	U makes do an act, M carries it out, comments and records the effects on the condition that the act is *feasible*
$Incomplete_U(p) \supset F^{FS}_M p$	if p incomplete M asks U to complete it p
$F^{s}_U p \supset Complete_M(p) \wedge F^{S}_M p$	if the answer of U is satisfied M completes p, if not it does it by default and notifies U
$Complete_M(p) \wedge p \blacksquare Plan \supset Cond^{F}(p)$	the act requested must be able to trigger a Plan to be manageable
$\neg Cond^{F}(p) \supset F^{P}_U b'$	if no plan is possible, then M suggests another goal
$F^{S}_U p \wedge Non\text{-}empty(p) \supset B_M p \wedge F^{S}_M p$	U gives an information, M records it if at least it is non-empty and comments its understanding of p
$F^{FS}_U p \wedge B_M p \supset F^{S}_M p$	U asks a question, M answers it if it knows the answer

$F^{FS}_{U}p \wedge \neg B_M p \supset F^{S}_{M}(\neg B_M p)$	U asks a question, M and explains if it does not know the answer
$F^{P}_{U}p \vee F^{D}_{U}p \supset F^{A}_{M}p \wedge B_M p$	M makes the proposed choice
$\neg F_U p \supset F^{p}_{M}p \wedge F^{S}_{M}b$	in case of non action of U, M goes back again to him with suggestions

3.5. THE CONTROL OF THE DIALOGUE

The control of the dialogue is the product of two distinct mechanisms controlled over the long term (putting into perspective of the conversational goals) and over the short term, local fit of the talking turns in relation to the goals of the exchanges and compared with the activity in the task.

The global management of the talking turns

The dialogue controller manages at the global level the sequence of the different phases of the dialogue, the breakdowns and the incidences. He encapsulates the local control of the dialogue described hereafter (called engine afterwards). It runs under the general algorithm as follows:

```
Dialogue
  Opening
  Exchange
        While StackGoal ≠ empty then Wait (Statement)
        If duration-wait > threshold then Boosting
        If ChangeofGoal then Breakdown
        If ChangeofTopic then Incidence
        Localcontrol(Statement, StackGoal)
      EndWhile
  Closing
EndDialogue
```

The local processing of the speech acts

The dialogue controller processes locally the speech acts into each talking turn, i.e. builds the answer to the statement $\alpha(t)$ of the user: he interprets $\alpha(t)$ in relation to the context, then generates an answer and possibly predicts the following act $\alpha(t+1)$ in view of a better understanding at the next turn. He operates according to a cycle that can be simplified as follows:

Stage 1: Pragmatic analysis of U's statement
Segmentation in speech acts
Computation of their different propositional contents
Stage 2: Computation of the best strategy
Application of the behaviour rules
Stage 3: Search for the plan to carry out
Scheduling of the goals of the task
Execution of the plan
Stage 4: Updating of the knowledge
Updating of the profile of U
Stage 5: Generation of the answer
Updating of the discourse history
Prediction of the following statement
Stage 6: Wait for the next speech act or statement from U

The handling of the incidences and of the breakdowns

The handling of the incidences and of the breakdowns is done through the help of specialized sub-dialogues that are triggered in the same way as the strategies. Once the sub-dialogue is initiated, rules of

behaviour allow to handle the problem like in an ordinary situation.

Triggering rules

An incidence: happens on an act that changes the theme. This starts a sub-dialogue but does not call into question the goal of the exchange, which is put on hold to be retrieved later

A breakdown: happens further to an unexpected change of goal

4. EXAMPLE OF MAN MACHINE DIALOGUE

The search for appropriate rules for the dialogue must be done from corpora acquired according to well-mastered experimental protocols [6], [3], then must be validated on test platforms which have man machine interfaces implementing them [1], [12]. Here is an example of realization with the rules of strategy adapted to the domain of the computer-aided drawing and the rules described above.

Statements	Acts	Strat.	Goals
M1: Welcome to ICPtalk	F^P		
do you know the system?	F^{FS}	D	?b1=B_M(u)
U: yes, a little	F^S		†b1 (u=occasional)
M2: I am presenting to you its main functions	F^P	C1	‡b1, ?b2=$F^F{}_U$(task)
1. the graphic edition...	F^S		
U: stop	F^F		†b2
I know	F^S		‡b2
I want ICPdraw	F^F		?b3=Run(ICPdraw)
M3: *action (ICPdraw)*	F^A	R	†b3
(U: <silence>)			‡b3
what do you want to do?	F^{FS}	C2	?b4= B_M(b)
I am waiting for your general intention	F^S		
U: ()	$\neg F^S$		-b4
M4: I expect an order	F^P	D	?b5=B_M(b')
U: draw a red circle	F^F		‡b5, ?b6 =b' (Circle1)
M5: *action (drawing circle)*	F^A	R	†b6
U: another, black	F^F		‡b6, ?b7 (Circle2)
M6: where? on the right of the 1st?	F^{FS}	N	b7'=b7. (A_right)
U: no, on the left	F^S		b7"=b7. (A_left)
M7: identical to the first?	F^{FS}	N	b7"'=b7."(size)
U: yes	F^S		†b7"'
M8: *action*	F^A		‡b7"'
what do they represent? wheels?	F^{FS}	C2	b4
U: draw a green square	F^F		-b4, ?b8 (Square1)
M9: *action*	F^A	R	†b8
U: and two others on the circles	F^F		‡b8, ?b9=(Square2.)(Square3)
M10: on each of the circles	F^{FS}	N	b9'=On(Square2,Circle1)
U: no, superimposed	F^S		b9"
M11: I do not understand…	F^{FS}	D	-b9", ?b10= B_M(Ref)
U: one above the other	F^S		†b10
M12: all right	F^S	R	‡b10
action (drawing)	F^A		‡b9"
yes, but for which figure?	F^{FS}	C2	b4
U: a flowchart	F^F		†b4, ?b10 =Drawing(Flowchart)
M13: oh ! I understand	F^S	R	‡b4, †b10
so I line up the figures	F^A		

I balance the spaces	FA		
U: yes, thanks, that's it	FS		‡b10
save that now	FF		?b11=Save(Flowchart)
M14: here + *action*	FA	R	†b11
U: thank you, that's all	FF		‡b11
M15: goodbye	FD	R	

5. CONCLUSION

The man machine dialogue (MMD) is fundamentally different from the human dialogue. The logic that we have described is not used to simulate a human dialogue with a machine, but to represent and formalize the mechanisms of the man machine dialogue, or rather of the verbal interaction since the interaction is done in relation to a task which underlies the dialogue. This logic is based on the beliefs, the goals and the acts and contains implicitly a deontic logic (as « social » obligations of the partners). By making the strategies of dialogue vary, one ends up with relatively natural dialogues. We have willingly considered that the MMD is a mechanism of handling of goals with a language component: it must connect a user with his task, with the assistance of the machine. It is thus through an operative and actional framework that we base our approach. This framework allows to give a more generic basis to the man machine interaction: one thus imagines rather easily that this model can adapt itself to any form of non language interaction.

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