

Analysis of a Recorded Team Coordination Dialogue

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Abstract—Our objective is to build software agents that can support the operations of coalition teams. One way to provide support is to handle some of the routine communication between human team members, allowing them to concentrate on the job of completing their tasks. To build agents that can do this job, we need to understand the kinds of communications that take place between the human team members. Accordingly we have analysed the communications that take place between team members completing a prototypical simulated task. In this paper, we describe two independent analyses of the transcript of the communication between members of a human team engaged in a military task. We give the results of the analyses, compare them, and summarise what we learned from the two exercises.

I. INTRODUCTION

This paper is concerned with managing collaboration in a team. In particular, we are interested in teams engaged in military missions, and teams in which members may come from different parts of an international coalition. In such situations, effective coordination can be problematic, with units unable to communicate easily, and handicapped by having been trained to operate under rather different doctrines. It is our contention that, with careful design, software agents can support effective collaboration in teams, and can overcome some of the problems experienced by coalition forces [1]. This paper reports on work towards such a design. In short, we are proposing that elements of the coordination is supported by software agents. The teams we are interested in are thus composed both of the human members of the units, software agents that support them, and possibly additional software team members (controlling, for example, autonomous vehicles). We use the term *hybrid-agent* to designate such teams.

One way to create effective hybrid-agent teams is to use agents to manage communication between team members. There are a number of ways that agents can do this effectively. For example, extrapolating from existing applications of software agents:

- Agents can filter messages, preventing unnecessary messages from reaching specific human team members, and

protecting them from distraction or information overload [11].

- Agents can coordinate the activities of human team members [3], again reducing the cognitive burden on human operatives.
- Agents can ensure that relevant information is passed between human team members, ensuring timely delivery of crucial data [13].
- Agents can help to enforce the correct protocol for team behavior, ensuring that human team members follow guidelines [6], [7].

For agents to be used in this way, they need to be programmed with some notion of what communication between human team members is expected, required, and allowed. While there has been a lot of research on what we might think of as *normative* communication between agents — that is the right way (in some sense) for agents to communicate — as, for example in [10], there has been little work on establishing the patterns of communication that agents might expect humans to use. This latter is exactly the subject of this paper, and it represents, to our knowledge, one of the first attempts to extract patterns of communication from human teams in a military context.

In particular, we present two separate analyses of a transcript of the communication between the members of a human team engaged in a military task. One analysis uses McGrath's [12] group functions, the other Walton and Krabbe's [16] typology of dialogues. As we shall see, these two approaches tell us complementary things about the communication. First, however, we describe the experimental setup.

II. DATA COLLECTION

The data we report in this paper were collected from an experiment carried out using the commercial game Battlefield 2 [2], suitably modified to capture, store, and manipulate activities and communications that occur during a simulated mission.



Fig. 1. The mission scenario for The Street in Battlefield 2, showing the starting positions of both teams.

A. The scenario

In the scenario we studied, a United Kingdom quick reaction force has the mission of finding and rescuing the pilot of a downed UK helicopter in a Middle Eastern city. This specific scenario is known as “The Street”. Figure 1 shows an overview of the Battlefield 2 map in which the scenario was enacted.

The background given to the coalition team was the following:

A coalition Blackhawk was shot down a few minutes ago. Constitute a quick reaction force to find the helicopter and its pilot. The town has been seriously damaged by air and ground assaults, and the local militias are very hostile. Your entrance and extraction of the pilot must be fast, because they are looking for her too. Fortunately, we have voice communication with the pilot. Once you reach the pilot, lead her out of the city.

With this background comes more specific instructions:

- 1) Enter the field of battle at *GB Start* (see Figure 1) with a team of Riflemen and a Combat Medic.
- 2) Proceed as quickly as possible to the downed helicopter at the east end of the main street.
- 3) Establish voice communication with the pilot and assemble your team at her location.
- 4) Escort her back to your entry point.

A second team, representing the local militia, were given similar background and instructed to prevent the UK team from accomplishing its mission.

B. The experiment

The results we analyse here were obtained in the context of a single simulation of The Street in which the UK team had four members who attempted to rescue the pilot. One of the experimenters played the role of the pilot, hiding

near the downed helicopter before the two teams began their missions. None of the participants were military personnel or had military training, but were experienced game players and knew how to move through the game environment with reasonable agility. The experimental infrastructure captured the locations of all players throughout the simulation, all the key events in the game, and all their spoken communications, and the complete simulation log was recorded.

Following the simulation, a transcript was produced of the spoken communications, and this formed the basis for the analyses reported below. In addition, there is an animation which combines the simulation events (as recorded in the log) and the spoken communication. This amounts to a movie of the experiment which was very helpful in understanding its details.

III. ANALYSIS BY GROUP FUNCTIONS

We used the commercial product *Atlas.ti* (see Figure 2 to perform a qualitative analysis of the voice data. Utterances were coded using a scheme based on Joseph McGrath’s theory of group functions [9], [12].

A. McGrath’s theory

McGrath’s theory describes group behavior in terms of two dimensions, as shown in Table I. The leftmost column and the topmost row correspond to these two dimensions. The leftmost column lists the four “critical modes of operation” that a team can undertake:

- 1) Inception describes all of the activities that a team may engage in when starting some project.
- 2) Problem-solving gathers all the activities that are related to deciding how to handle problems that arise while completing the task but are not directly related to the task itself.

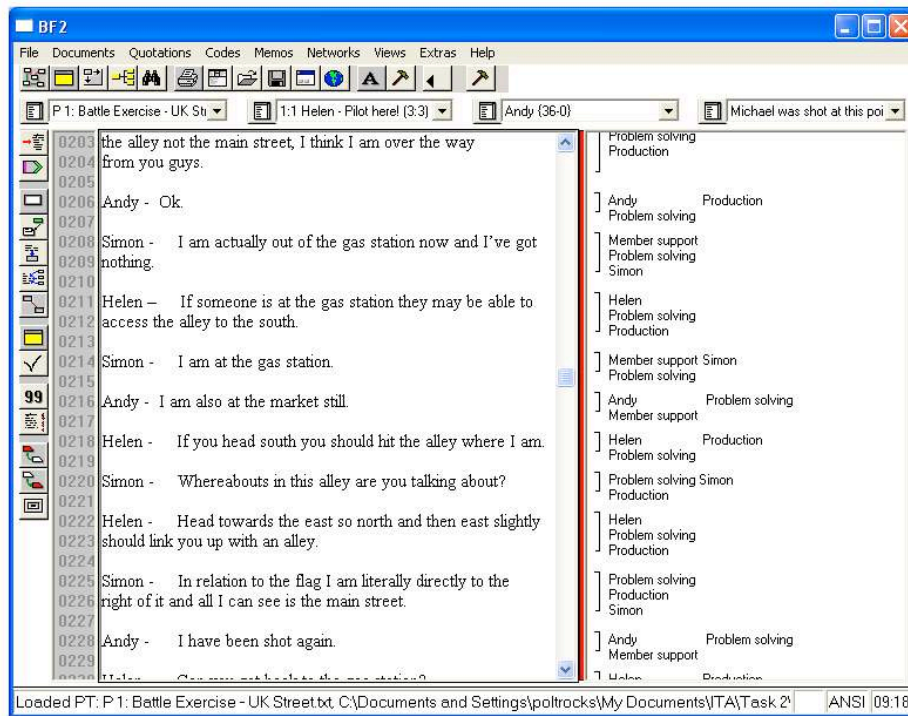


Fig. 2. Analysis of part of the transcript in Atlas.ti.

- 3) Conflict-resolution describes all the activities that deal with conflicts within the group.
- 4) Execution covers the actual completion of the task.

The columns correspond to three different team objectives. Production includes activities that contribute to the completion of the project. Group well being includes activities that contribute to the health of the group as a whole. Member support includes activities contributing to the well-being of the individuals in the group.

The activities in the cells are examples of group behavior that correspond to the intersection of each pair of dimension values. Research and development intended to support teams often focuses on just one of these cells at the intersection of production and execution, but research on technology adoption has demonstrated that people will not use technologies that interfere with group well-being and member support [5].

B. The analysis

We applied McGrath's coding scheme to all the utterances from the transcript of the scenario. The results are summarized in Table II. Note that almost all the conversation in this mission was either about solving problems or executing the mission. The rarity of conversation related to mission inception is probably because this team had previously attempted to perform the same mission and had already completed that phase of conversation. (Later experiments, in which teams members are less familiar with the task, show more conversations about inception.) It is striking how little conflict, and consequently conflict resolution, emerged in their conversation. This team

was in continuous agreement about what to do and how to do it.

It is also worth noting that problem solving occurred regarding production, group well-being, and member support. Some examples may help illustrate the differences between these three categories of group function. Early in the simulation one member of the team said,

What are we going to do now? I'm expecting to start taking fire on the north side of the street having just killed one of their men.

This soldier is identifying a production problem; they need a plan that will enable them to complete their mission despite expected enemy fire. Later, another soldier began taking fire and said,

I've been shot!

In McGrath's coding scheme, this statement also defines a problem, but in this case the problem is much more personal, and it constitutes a request for member support. In a short conversation, one soldier asked:

Did you just get hurt jumping off there?

His companion responded,

Yes, you lose a little bit of health but just a sprained ankle. You're a soldier.

The first soldier responded,

One for the team!

This kind of conversation fosters group well-being.

	Production	Group well-being	Member support
Inception	Production demand and opportunity	Interaction demand and opportunity	Inclusion demand and opportunity
Problem-solving	Technical problem solving	Role network definition	Position and status achievements
Conflict resolution	Policy resolution	Power and payoff distribution	Contribution and payoff distribution
Execution	Performance	Interaction	Participation

TABLE I
THE TWO DIMENSIONS OF GROUP BEHAVIOR

	Production	Group well-being	Member support
Inception	1	3	8
Problem-solving	64	24	20
Conflict resolution	0	0	0
Execution	46	17	1

TABLE II
ANALYSIS OF UTTERANCES BY GROUP FUNCTION

Note that much of the conversation was about problems, and this is exactly the type of conversation that has the potential to reveal opportunities to provide timely assistance. These conversations were primarily about two problems they encountered when performing this mission. The first problem can be summarized as:

Where are they shooting from?

Frequently when soldiers were wounded they had not seen who had shot them and had no clear idea regarding the direction of fire. It was difficult for them to take cover when they did not know the direction of fire. For example, one soldier said,

I have been shot. I'm still alive. I don't know which side I got shot from.

Later he continued,

I've just retreated to the back of the market because I got shot at. I couldn't tell from which direction, I suspect south.

The second problem can be summarized as:

How do I get from here to there?

The team quickly determined the location of the pilot and they could identify her position on a rough map, but they had great difficulty finding a route to her location because streets that were visible on the map were often blocked at one end, creating a challenging maze.

IV. ANALYSIS BY DIALOGUE TYPE

In our second analysis we classified each utterance by the type of dialogue to which it contributed. The typology that underpinned this classification is that of Walton and Krabbe [16].

A. The typology

Walton and Krabbe's typology identifies six basic types of dialogue:

- 1) **Information-Seeking Dialogues** One participant seeks the answer to some question(s) from another participant, who is believed by the first to know the answer(s);

- 2) **Inquiry Dialogues** Participants collaborate to answer some question or questions whose answers are not known to any one participant;
- 3) **Persuasion Dialogues** One party seeks to persuade another party to adopt a belief or point-of-view he or she does not currently hold. Persuasion dialogues begin with one party supporting a particular statement which the other party to the dialogue does not, and the first seeks to convince the second to adopt the proposition. The second party may not share this objective.
- 4) **Negotiation Dialogues** The participants bargain over the division of some scarce resource in a way acceptable to all, with each individual party aiming to maximize his or her share. The goal of the dialogue may be in conflict with the individual goals of each of the participants.¹
- 5) **Deliberation Dialogues** Participants collaborate to decide what course of action to take in some situation. Participants share a responsibility to decide the course of action, and either share a common set of intentions or a willingness to discuss rationally whether they have shared intentions.
- 6) **Eristic Dialogues** Participants quarrel verbally as a substitute for physical fighting, with each aiming to win the exchange.

Walton and Krabbe allow for dialogues to be combinations of these different types, and they admit that this classification may not be complete. Indeed, several authors have identified alternative types of dialogue — Girle, for example, discusses command dialogues [8] while Cogan *et al.* [4] describe a series of question-led dialogues that are distinct from Walton and Krabbe's information-seeking dialogue.

B. The analysis

There are 184 utterances in the transcript of which 12 are either meaningless from the perspective of the Walton and Krabbe typology, for example, utterance 4,

Stay alive

or which we found impossible to identify as part of any dialogue, such as utterance 36.

That one, no that one

Taking the remaining 172 utterances, all of which were clearly part of an identifiable conversation between the members of the human team, and classifying them into the nearest of Walton and Krabbe's categories, we get the results summarized in Table III. Since this accounts for 90 statements only, we

¹Note that this definition of negotiation is that of Walton and Krabbe. Arguably negotiation dialogues may involve other issues besides the division of scarce resources.

Information seeking	40
Inquiry	0
Persuasion	0
Negotiation	0
Deliberation	50
Eristic	0

TABLE III
CLASSIFICATION OF UTTERANCES INTO WALTON AND KRABBE'S
DIALOGUE TYPES

clearly have 82 utterances that do not fit into the dialogues types identified in [16]. We will return to these shortly.

As Table III shows, all the utterances that fall into dialogues identified by Walton and Krabbe are part of either information seeking or deliberation dialogues — there were no persuasion, inquiry or negotiation dialogues. This is not surprising. For a team carrying out a task, it is to be expected that a large part of their conversation will be centered around the question of how to complete the task, and this is the realm of deliberation. Furthermore, given that, as discussed above, the participants' main difficulty in completing the mission is finding their way around, the large number of utterances relating to Information seeking are only to be expected as participants try to gain information about which way to go.

Note that in classifying the utterances in this way, we were fairly liberal in our interpretation, though justifiably so. For example, one utterance that we classified as part of a deliberation is utterance 16:

What's the best way of getting across, just leg it?

This is not the careful consideration of different courses of action that is described in [16], but it is part of a conversation about what action to take, and "deliberation" is the only form of dialogue in the typology in which actions are discussed. Thus it seems appropriate to classify such utterances as part of deliberation dialogues. Similarly, we stretched the meaning of "information seeking" in some places. A strict interpretation of this kind of dialogue requires the questioner to believe that the person they are questioning knows the answer. Some of the utterances in the transcript are like utterance 53:

Was that you?

where the questioner is unsure who they are addressing and whether anyone can answer, but needs the information and so asks anyway. Since no other types of dialogue in the typology deal with questions, it seems reasonable to classify utterances like those above as part of information seeking dialogues.

Also note that, in keeping with the Walton and Krabbe model, many of the dialogues we identified are nested in one another. 16 of the 40 Information-seeking utterances are embedded in Deliberations — as part of a discussion about what to do, somebody asks a question.

Now, the 82 utterances that don't fall into dialogues in the Walton and Krabbe typology are also interesting. All of these are of the same type. They are statements like the following (utterance 9):

Ok, from my position here I can see an alleyway

	Not embedded	Embedded in deliberation
Information seeking	18	22
Information providing	40	42
Inquiry	0	0
Persuasion	0	0
Negotiation	0	0
Deliberation	50	0
Eristic	0	0

TABLE IV
CLASSIFICATION OF UTTERANCES INTO WALTON AND KRABBE'S
DIALOGUE TYPES EXTENDED WITH THE INFORMATION PROVIDING
DIALOGUE

which runs due west from my position past the main street.

and (utterance 41):

I have been shot

If these statements were made as a result of questions about the speaker's position or status, then they would be part of an information-seeking dialogue, but in every case, *no such question has been asked*. As a result, we have a new form of dialogue — new in the sense that it hasn't been identified by work that we are aware of — in which participants put forward information that they believe will be of use to the other participants. By analogy with the information seeking dialogue, we call this an *information providing* dialogue, and a formal model for such a dialogue may be found in [14]. Just as is the case for Information seeking, Information providing dialogues are embedded in Deliberations — 42 of the 82 Information providing utterances are so embedded.

Table IV summarizes the results, including this new type of dialogue and the observed embeddings.

V. COMPARING ANALYSES

Now that we have presented the two analyses, what can we learn from comparing them?

A. A high-level comparison

The two analyses presented above are somewhat complementary. Both approaches aim to classify dialogues by their content, but they measure that content in different ways. The Walton and Krabbe typology looks at the intention of the dialogue — to decide a course of action, to discover information — but does not really consider the context in which that dialogue is held. A deliberation dialogue is a deliberation dialogue whether it is concerned with deciding on where to go and have dinner, or whether it is concerned with how to extract a crashed pilot. The McGrath typology focuses more on the intention of group behavior — which in this case is limited to conversation — but within the wider context of the activity that the group is involved in. This leads to the distinction between, for example, problem solving related to production (how to recover the pilot), and problem solving related to group well-being (where to go for dinner).

As a result of this partial complementarity, there is not a simple mapping between the two analyses. In some places the relationship is simple. As we have already pointed out, all

	Information seeking		Information Providing		Deliberation	Not-coded	
	Embedded	Not-embedded	Embedded	Not-embedded		Embedded	Not-embedded
Production/Inception	0	0	0	1	0	0	0
Production/Problem Solving	5	9	11	12	26	2	0
Production/Conflict Resolution	0	0	0	0	0	0	0
Production/Execution	2	10	3	20	8	1	2
Total	7	19	14	33	34	3	2
Group Well-Being/Inception	0	0	0	0	0	3	0
Group Well-Being/Problem Solving	6	0	6	6	6	0	0
Group Well-Being/Conflict Resolution	0	0	0	0	0	0	0
Group Well-Being/Execution	2	3	7	1	4	0	0
Total	8	3	13	7	10	3	0
Member Support/Inception	1	0	1	1	2	3	0
Member Support/Problem Solving	3	0	12	0	4	1	0
Member Support/Conflict Resolution	0	0	0	0	0	0	0
Member Support/Execution	0	0	0	1	0	0	0
Total	4	0	13	2	6	4	0

TABLE V

COMBINING THE TWO CLASSIFICATIONS — EACH LOCUTION CLASSIFIED USING BOTH IN TERMS OF McGRATH'S GROUP FUNCTION AND WALTON AND KRABBE'S DIALOGUE TYPES.

forms of problem solving are deliberations. Similarly, conflict resolution maps to different types of persuasion dialogue (though such persuasions may be embedded in deliberations, when the conflict is to do with production). However, in other places there is no obvious relationship. As an example, information seeking and information providing have no simple relationship with the elements of the McGrath classification. Depending on the context, utterances that are information seeking or information providing can fall into a number of different classes in McGrath's terms. For example, utterance 76:

I am in the alley not the main street, I think I am over the way from you guys

is information providing while utterance 83:

Whereabouts in this alley are you talking about?

is information seeking, but both are also problem-solving/production utterances as well.

Since the analyses are partially complementary, what we learn from them is partially complementary. Both analyses make it clear that the main focus of the conversation in the transcript is on the business of how best to complete the mission, whether this is classified as problem solving or deliberation.² Equally, both analyses are very clear that this team is not in any kind of conflict — we see neither conflict resolution activities (which might mean there is conflict that is not resolved) nor do we see any kind of persuasion dialogue (which would indicate disagreements).

However, each analysis also gives us useful information that is not available from the other. As Table II shows, the McGrath analysis makes clear the extent to which the team

²Indeed, given that the analyses were carried out completely independently — Poltrock first completed the analysis using McGrath and then Parsons and Tang completed the analysis using Walton and Krabbe before they looked at the results of Poltrock's analysis — they agree surprisingly exactly. Table II gives 64 + 24 + 20 = 108 problem solving utterances, while Table IV gives 50 deliberation utterances with a further 18 + 40 utterances embedded into the dialogues from which those utterances come, for a total of 108 utterances in deliberation dialogues.

is concerned with the well-being of the group as a whole (45 utterances) and with providing support for group members (29 utterances). These are aspects that are not obvious from the Walton and Krabbe analysis. Similarly, as Table IV shows, the Walton and Krabbe analysis exposes, through the number of information seeking utterances, how much the team is groping for the information that it needs. In addition, this second analysis shows, through the number of information-providing utterances, the degree to which this team relies on human team members identifying and relaying information that is relevant to team performance.

B. A locution-level comparison

We can also take a more detailed look at the results of the two analyses. Some time after coming up with the initial classifications, we combined the two, allowing us to look at how each locution was classified in both schemes. (The combined classification is available in [15].) The result of this classification is given in Table V.

The combined classification tells us a few new things about the dialogue. We already know that most of the locutions are classified in the McGrath scheme as Production, and that least are classified as Member Support, and so it is no surprise to find that this pattern is reflected in the breakdown of the locutions that are classified as Deliberation in the Walton and Krabbe scheme. However, the locutions in the other Walton and Krabbe dialogue types don't match this pattern. There seems, for example, to be proportionally little use of Information Seeking in Member Support, but proportionally a lot of unembedded Information Providing (there are approximately the same number of such locutions in all three of McGrath's classes). Thus it seems that the team members weren't asking each other how they were doing, but tended to initiate conversations that told each other this information. Similarly, there was a proportionately large amount of embedded Information Seeking and Information Providing in the Production parts of the dialogue, so this seems to be a phase in which the team shared a lot of information.

VI. CONCLUSION AND FUTURE WORK

This paper has described two analyses that classified the utterances in an example of a team coordination dialogue. The analyses used different classifications, and were carried out independently. The paper not only described the results of the analyses, which are useful in guiding our work to build software agents to support team operations, but also compared the classifications that the analyses provided, giving some insight into the pros and cons of the different techniques.

There are two lines of future work that we are currently pursuing. First, we are using the insights from these analyses to build software agents that can support team performance (this was, after all, one of the objectives in undertaking the analyses in the first place). To date this work has led to the development of a formal model of the information providing dialogue identified here [14], and the next step is to provide an implementation. Second, we are applying the same analytical techniques to further examples of team coordination. Experiments to generate such dialogues have already been carried out, and we are waiting for the transcription of the recordings to be completed.

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