Combining deontic and action logics for collective agency

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Abstract. In this paper we address the problem of collective norms, and discuss two action logics for that purpose. The first action logic is based on the action modality E_i, where expressions of the form E_ip are read as 'agent *i* brings about (sees to it) that *p*'. This operator relates an agent with the effects of his action, and abstracts away details of the specific actions. We will show that this abstraction often leads to an unacceptable level of ambiguity. Therefore we have developed another action logic, which is an extension and a variant of dynamic logic. The extension consists of groups of agents to express collective actions for representing collective norms.

1. Introduction

Conventional approaches to deontic logic[1] employ impersonal deontic operators, so without revealing the identity of the persons involved. These approaches implicitly refer to one and the same individual all the time, explicit reference being unnecessary (cf. [9]). They are limited, since they are not able to deal with problems related to (groups of) agents.

Some researchers (e.g. [1],[6],[8], and [13]) tried to include relativised deontic modalities in standard deontic logic (SDL) and to define 'personal' obligations and permissions in terms of the 'impersonal' ones. The common reduction of the personal to the impersonal obligation – originated by Hilpinen ([8]) – is expressed by:

$$O_iA =_{def} OE_iA,$$

meaning that A is obligatory for *i'* is defined by 'it is obligatory that *i* sees to it (brings about) that *A*'. *A* expresses a state of affairs and E_i is an intentional action operator proposed by Kanger ([12]). The expression E_iA describes a class of actions that can be performed by actor *i* to bring it about that *A*. Jones and Sergot make the following observation about this operator:

> the 'brings it about' operator abstracts away details of specific actions performed by the agents, changes of state, and the temporal dimension generally; we have indicated that for certain purposes this abstraction is appropriate. But in the context of computer systems, a specification employing this operator would be a formal specification at an unusually high level of abstraction. (...) [I]t is clear that some aspects of access control mechanisms and some of the

1 Deontic logic is a branch of philosophical logic concerning reasoning about norms, or in other words, about normative versus non-normative behaviour. It is the logic of obligations, prohibitions and permissions.

Lambèr Royakkers, 'Combining deontic and action logics for collective agency', in: Joost Breuker, Ronald Leenes and Radboud Winkels (eds.), *Legal Knowledge and Information Systems. Jurix 2000: The Thirteenth Annual Conference.* Amsterdam: IOS Press, 2000, pp. 135-146.

> behaviour of distributed computer systems need to be modelled at a finer grain of detail. In these cases, it will be necessary to replace or augment use of the "brings it about" operator with more standard approaches to action and time in computer science. ([10])

However, as we will show, this approach allows a certain ambiguity to the interpretation. For example, the reading of 'John brings it about that the door is open' is ambiguous in that, since it fails to discriminate between 'John opens the door' and 'John keeps the door open' (cf. [20]).

Another shortcoming of this operator in the scope of a deontic operator is that only the results (the consequences) are of any interest. The actions which lead to the states of affairs are neglected in this consequential view. Of course, many human actions are described by their results, something on which Von Wright in particular has focussed (see [25]). However, sometimes we need a more deontological view in which the actions are central. Such a deontological approach fits better in the system of criminal law, since it is mainly concerned with behaviour: if an illegal situation is mentioned in the description of an offence, the question is raised as to who created this situation by which action or by omission, and who is responsible for continuing the situation (omission). From the illegal situation a certain type of behaviour is derived, so to speak. The type of behaviour (performance/action) determines the sanction. So, not only in the context of computer systems we need a 'finer grain of detail'. Dynamic logic is a useful system for the modelling 'at a finer grain of detail', since it contains the following aspects:

1. Actions and assertions are strictly separated;
2. Actions can be made explicit, so the notion of ambiguity disappears;
3. A notion of time-lag is built in ($[\beta]\Phi$ means that assertion Φ holds after the action β is performed).

In this paper, we will present a language with which we can describe events: (interpreted) actions performed by (groups of) agents. The language is a variant and an extension of Harel's ([7]) dynamic logic and Meyer's ([18]) deontic dynamic logic. The addition of groups of agents to express collective obligations is rather new in dynamic logic and offers extended expressive power. A collective obligation is an obligation aimed at a particular group of agents and not aimed at every agent of that group. We will show that it often depends on the type of action when a group fulfils its obligation. For example, if a group of agents has to pay for their meals, the obligation is fulfilled if one agent of the group pays. But, if the group is obligated to be quiet, then all the agents have to be quiet to fulfil the obligation. This can easily be represented in an extension of dynamic logic, but not in the extension of the 'brings it about' operator, since this operator neglects the action that leads to a certain state of affairs. The motivation for this extension is that:

- There are situations that only can be accomplished by a group;
- We can express group liability (e.g. liability for a trading partnership).

Moreover, Pacheco and Carmo ([19]) concluded that collective agency in law cannot be avoided, such as the entity 'artificial person' which aggregates several persons allowing them to collectively pursue some interests with juridical personality and legal competence.

The paper is structured along the following lines. In section 2, we discuss the action component E_i and some extensions which are useful to add to our theory of collective obligations. Section 3 presents the logic of events, an extended variant of dynamic logic, and the combination with deontic operators to express individual and collective norms. The collective obligation will be discussed in section 4 and we end with some conclusions.

2. On the action component E_i

A disadvantage to relativise the O-operator is that we cannot make a distinction between ‘it is obligatory that *i* brings it about that not *p*’ and ‘it is obligatory that *i* does not bring it about that *p*’. In the formalisations of relativised deontic modalities only the first sentence is represented: $O_i(\neg p)$. The distinction between the above sentences can be made by constructing the class of (individual agent) act-positions to express a new class of normative positions developed by Kanger ([12]) and Lindahl ([15]). The treatment of act descriptions employs a relativised monadic operator E_i. The expression E_ip is read as ‘actor *i* brings it about that *p*’ or ‘actor *i* sees to it that *p*’. Although, there are some different logics of the action operator E_i[2] most logical systems contains the following two axiom schema:

(T) $E_ip \rightarrow p$
(C) $(E_ip \wedge E_iq) \rightarrow E_i(p \wedge q)$

and the rule

(RE) $$\frac{p \leftrightarrow q}{E_i p \leftrightarrow E_i q}$$

The axiom schema (T) indicates that this is a notion of *successful* action. The sentence OE_ip is read as ‘it is obligatory that *i* brings it about that *p*’. Now we have four atomic types of obligations (cf. [17]) instead of two atomic types O_ip and $O_i \neg p$:

1. OE_ip: ‘it is obligatory that *i* brings it about that *p*’.
2. $OE_i\neg p$: ‘it is obligatory that *i* brings it about that not *p*’.
3. $O\neg E_ip$: ‘it is obligatory that *i* does not bring it about that *p*’.
4. $O\neg E_i\neg p$: ‘it is obligatory that *i* does not bring it about that not *p*’.

The first two expressions seem to correspond with what is meant in the formalisations of relativised deontic modalities:

- $O_ip = OE_ip;$
- $O_i\neg p = OE_i\neg p.$

These two definitions originated by Hilpinen (see [8]) are criticised by Krogh and Herrestad ([14]). Hilpinen proposes to equate a sentence expressing the personal obligation of an agent *i* (O_ip) by a sentence expressing the impersonal obligation that agent *i* does something (OE_ip). So, this relation expresses that ‘*p* is obligatory for *i*’ is equivalent to ‘it is obligatory that *i* sees to it that *p*’. The criticisms of Krogh and Herrestad are from a logical point of view. They show that the reduction of Hilpinen gives rise to some counter-intuitive results. For example, the interdefinability of the personal permission and personal obligation ($O_ip \equiv \neg P_ip$) is not valid. However, this is not a crucial problem, since the interdefinibility is rejected by most deontic logicians and they treat both *O* and *P* as basic and not interdefinable. Another problem, more crucial, is the fact that schema $OE_iE_jp \rightarrow OE_jp$ becomes a theorem, which is unacceptable, since from a personal obligation on *i*, we may infer a personal obligation on *j*. A possible solution to avoid this is to weaken the rule (RM): $\frac{p \rightarrow q}{O_p \rightarrow O_q}$. However, this rule is essential in most deontic logics and without this rule

[2] For a brief overview of these action logics, see [24].

the logics become very weak with the result that they are of no use in practice.[3] Another solution is to restrict the syntax of the action logic by forbidding iterating action modalities, such as $E_iE_j\ p$ (made j do) or $E_i\neg E_j\ p$ (made j avoid). The consequence of this is that we cannot express for example the notion of control which is a basic ingredient for joint intentions, true cooperation and team work (cf. [3]).[4] Besides these logical objections, there is a more philosophical objection to the reduction of Hilpinen. With respect to the obligation O_ip, the personal obligation is fulfilled if p is true regardless of who has made p true. For example, if i is obliged to pay for his meal, his obligation is fulfilled if a stranger pays for his meal even without the notice of i. However, this cannot be expressed by the personal obligation OE_ip, meaning that there is an obligation for an individual action of i to see to it that p, which is violated in case agent i does not cause p by himself. The obligation is only fulfilled if i brings about the state that p is the case, for example by paying or by instructing the stranger to pay for his meal. The difference may seem subtle, but is very relevant for the scope of this paper.

2.1 Institutionalised power

We can overcome this problem by adopting the conditional operator $\Rightarrow_s$, where expressions of the form $p \Rightarrow_s q$ are read 'for organisation/institution/normative system s, p counts as q', adapting the idea presented and formally characterised in Jones and Sergot (cf. [11]). Now, we can also express that 'according to institution/organisation s, if agent x sees to it that A then y sees to it that F': $E_xA \Rightarrow_s E_yF$ 'The idea here is, clearly, that x's seeing to it that A must be an effective way of exercising power so that, relative to s, the state of affairs described by F becomes a matter of fact' (cf. [11], p. 353). The stranger's power to pay for the meal of i can now be represented by $E_jp \Rightarrow_s Eip$, where s is the restaurant, and j the stranger, which can be read as that the payment of i's meal by j for the restaurant counts as the payment by i. So, the obligation OE_ip – which is in fact a directed obligation towards the restaurant – is according to the restaurant fulfilled if the stranger j pays the meal of i.

2.2 Ambiguity

Jones and Sergot combine their notion of 'institutional power' with deontic logic, and show the expressive richness of the multi-modal language. However, their examples give rise to comments, since they show certain ambiguity. In their system the following formula – probably based on the catholic canonical law – is consistent:

$$(E_pr \Rightarrow_s E_sm) \wedge \neg PE_pr \wedge PE_pm, \qquad (1)$$

where p stands for the priest, r stands for 'the ritual', m stands for 'the couple is married', and s for the Church. The formula $E_pr \Rightarrow_s E_sm$ represents the priest's power to marry some couple by performing ritual r. 'Here, the priest p is forbidden by the Church to exercise his own power to create the marriage, but the Church does not go so far as to prohibit all action which p might take to bring about the marriage: p is not forbidden, in particular, to act as a layman in this matter, and to see to it that some other empowered agent performs the marriage'.

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3 From a theoretical view, some deontic logicians have weakened the rule (RM) to show that some paradoxes in deontic logic will disappear.

4 The question still is whether E_iE_jp expresses a notion of control. If i just causes (perhaps accidentally) that j brings about p, then this is not 'control' at all, but simply 'interference'. This limitation is relative to the problem of expressing the intentionality of the action.

Here they apply double standards: the action component E_p in this example has two meanings. In E_pr it stands for '*p* performs' and in E_pm it stands for '*p* brings about that'. If we use the usual reading of E_pr, then it stands for '*p* brings about ritual *r'*, with the consequence that the prohibition of this is odd; *p* is not forbidden, in particular, to act as a layman in this matter, and to bring about that some other empowered agent performs the ritual.

Krogh and Herrestad ([14]) also give an example derived from catholic canonical law in which the ambiguity of the action component E_x appears. Assume that a duty of the man of a married couple is the pregnancy of his wife. Let *q* stand for the state of affairs that *i*'s wife is pregnant. The duty would be represented in the action logic as OE_iq: 'it is obligatory that *i* sees to it that his wife is pregnant'. Especially, if we take into account that in most of these theories (e.g. [8]) to accomplish normative coherence the following implication holds $OE_iq \rightarrow PE_jq$. Thus, if it is obligatory for *i* to bring about that his wife is pregnant, then it is permitted for an arbitrary agent *j* to bring about that *i*'s wife is pregnant. It might be clear that the representation of the duty of the man by OE_iq is not exactly the representation the Church has in mind.

The problem with the representation of norms with the action component is that it is ambiguous with respect to norms that are aimed at one particular person and are private. Therefore, it is hardly possible to represent a prohibition for an individual *i* to bring about *A* if that prohibition does not hold for every individual, say *j*, since we can imagine that it is not forbidden that *i* sees to it that *j* performs some actions to accomplish the state of affairs expressed by *A*. Therefore, we will introduce in the next section a logic of events based on dynamic logic in which the ambiguity disappears. But first, we will discuss an extension of the action modal operator E_i, which can be used to solve this problem partially.

2.3 The notion of quality (role)

When an agent acts, he always acts in some role. For example, a decorator of a painting business who paints the wall black instead of white acts as a representative of the firm, which leads to a violation for which the firm bears the responsibility. In a juridical view, the owner of the house can make the firm responsible. However, if the decorator acts as himself, thus not authorized by the organisation or by working on the side, the owner has to make the decorator responsible. From this it follows that authorization is an important notion.

In [2], Carmo and Pacheco introduce the notion of quality (role) in which an agent acts. This idea can partially solve the ambiguity, since now we can express that an agent may be permitted to bring about some state of affairs, but forbidden when playing other roles. They assume with respect to this notion the following three principles:[5]

1. $E_{i\ acting\ as\ adm.\text{-}of\ (k)}\ B \rightarrow E_iB$: meaning that 'if *i* sees to it that *B*, acting in some quality, *i* sees to it that *B'*;

2. $E_{i\ acting\ as\ adm.\text{-}of\ (k)}B \rightarrow E_{k\ acting\ as\ himself}\,B$: meaning that that 'if *i* sees to it that *B*, acting in some quality/as a representative of *k*, then this counts as if it was *k* himself that was acting.

3. $E_{i\ acting\ as\ adm.\text{-}of\ (k)}B \rightarrow :\ E_{i\ acting\ as\ himself}\,B$: meaning that 'if *i* sees to it that *B*, acting in some quality/as a representative of *k*, then this does not count as if it was *i* himself that was acting.

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5 With the preassumption that 'if *i* sees to it that B, acting in some quality ('as administrator of'), *i* possesses that quality'.

Consider the priest example. Now we can represent the prohibition of the Church s as follows:

$$\neg PE_{p\ acting\ as\ administrator\text{-}of\ (s)}m;$$

meaning that the priest p is forbidden by the Church to exercise his own power (as a administrator of the Church) to create the marriage, but he may act in other roles, such as a witness.

However, the notion of quality as defined by Carmo and Pacheco neglects the fact that the performance by the administrator of some institution of some designated action to bring about p is often not the same state of affairs which is established as a matter of institutional fact. Consider the example (taken from Jones and Sergot) of the submission of a research grant proposal. A grant proposal is produced (g) within some University Department s when the Head of Department h adds his signature to the completed proposal form (f). This would be represented as

$$E_{h\ acting\ as\ administrator\text{-}of\ (s)}f \rightarrow E_{s\ acting\ as\ himself}f;$$

but we cannot express that his signature leads to the submission of the grant proposal as a matter of institutional fact. Useful would be to combine the notion of 'counts as' and the notion of 'quality', which can lead to the following representation of the above example:

$$E_{h\ acting\ as\ administrator\text{-}of\ (s)}f \Rightarrow_s E_{s\ acting\ as\ himself}\ g:$$

In the theory of Carmo and Pacheco ([2]), the relation between the individuals and the collective one (in which the individuals participate) is totally neglected by ignoring that a collective agent is a set of individuals. The consequence is that it remains rather obscure how the obligation flows from the collective agent to the individual ones. In their theory this happens just by definition. Formally it works, but conceptually it is not very clear.

3. A logic of events

In this section, we introduce a simplified version of the semantics of collective event expressions $X : \beta$ where X stands for a group of agents and β for an action. Actions are the semantic counterparts of the action expressions used in dynamic logic.

3.1 The action expressions

The semantics of an action expression is a set of sets of actions. We define A as the set of action symbols. An atomic action is denoted by an underlined action symbol ($\underline{a}$).
$\underline{A}$ is the set of positive (see below) atomic actions. Furthermore, we define a special action symbol δ, which is not an element of A, and which models failure. Together, they constitute the set of semantic elementary actions.

The set of all action expressions Act can now be determined by the following BNF for its elements (β)

$$\beta ::= \underline{a}\ |\beta_1 \cup \beta_2 \mid \beta_1 \& \beta_2 \mid \overline{\beta}\ \mid \textbf{any} \mid \textbf{fail}.$$

The meaning of $\beta_1 \cup \beta_2$ is a choice between β_1 and β_2, $\beta_1 \& \beta_2$ stands for the simultaneous performance of $\beta_1 \& \beta_2$, and $\overline{\beta}$ stands for the negation of action expression β. The **any** action expression indicates a universal or 'don't care which' action. Finally, the **fail** action expression expresses the action that always fails. After this action, the system stops and nothing can be done any more.

Now we will introduce two special kinds of actions: the *positive* and *negative* actions. These actions are very fruitful for the determination when a group of agents fulfils an obligation, since it makes a difference whether a group performs a positive or a negative action. A positive action is an action that involves a certain kind of physical activity: a bodily movement and muscular activity, whereas a negative action refers to refraining from a physical activity: an omission. For instance, 'to move the table', 'to close the window', 'to walk', 'to overtake', etc., are all positive actions and 'not move the table', 'to be silent', 'not walk', etc., all constitute negative actions. However, the difference between positive and negative actions is not clear cut, because (1) in several cases it is difficult to decide whether an action is positive or negative, and (2) a negative action is a non-action and, at the same time, a 'mode of action or conduct'.

Omissions are imputed to actors, and have to be taken into account in the dynamic variant of the logic of action that treats omission as different from merely not performing some action. We define omissions (negative actions) in terms of non-performance and in terms of the notions of *ability* and *opportunity* (cf. [16]). In this view, someone omits (neglects) doing something if he can do it, but does not do it.

Definition 1

1. *the set Act_p of positive action expressions by the following BNF for its elements (γ):*

   $\gamma ::= \underline{a} \mid \gamma_1 \cup \gamma_2 \mid \gamma_1 \& \gamma_2 \mid$ **any,**
   with γ_1; $\gamma_2 \in Act_p$, and

2. *the set Act_n of negative action expressions by the following BNF for its elements (γ):*

   $\gamma ::= \overline{\underline{a}} \mid \gamma_1 \cup \gamma_2 \mid \gamma_1 \& \gamma_2 \mid$ **fail,**
   with γ_1; $\gamma_2 \in Act_n$.

Note that

- $\underline{A} \subset Act_p$, so all atomic actions are positive actions.
- $Act_p \cup Act_n \subset Act$. The converse ($Act_p \cup Act_n \supset Act$) does not hold because, for instance, $\underline{a_1} \& \overline{\underline{a_2}} \in Act$, but is not an element of $Act_p \cup Act_n$.
- $Act_p \cap Act_n = \emptyset$
- $\gamma \in Act_n$ *iff* $\overline{\gamma} \in Act_p$.

3.2 The event expressions

The set of agents is denoted by *I*. An atomic collective event is an action initiated by a group of agents actor. (For short, we will write 'events' instead of 'collective events' in the sequel.) An atomic event is denoted by a group of agents X ($\subseteq I$) and an action β as follows: $X : \beta$. We define $\underline{Evt}$ as the set of atomic events.[6]

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[6] Note that an action β in an atomic event is not necessarily an atomic action.

The set of all event expressions *Evt* can now be determined by the following BNF for its elements (α):

$$\alpha ::= X : \beta \mid \alpha_1 \cup` \alpha_2 \mid \alpha_1 \&' \alpha_2 \mid \overline{\alpha},$$

where $X \in \mathcal{P}^+(I)$, with $\mathcal{P}^+(I)$ the non-empty powerset of I, α_1, $\alpha_2 \in Evt$ and $\beta \in Act$.

The meaning of $\alpha_1 \cup` \alpha_2$ is a choice between α_1 and α_2. Furthermore, $\alpha_1 \&' \alpha_2$ stands for the simultaneous performance of α_1 and α_2, and $\overline{\alpha}$ stands for the negation of event expression α. The event expression X : **any** means that X performs a universal ('do not care which') action. Finally, the event expression X : **fail** means that X performs an action that always fails. After this event, the system stops and nothing can be done any more. Note that the meanings of these event expressions correspond with the meanings of the action expressions, except that groups of agents are added here.

The performance of an atomic event, e.g. $X : \underline{\alpha_1} \& \underline{\alpha_2}$ (e.g. to pay & to whistle) involves the performance of the (semantical) elementary actions α_1 (to pay) and α_2 (to whistle), possibly together with other elementary actions. The meaning of $X : \underline{\alpha_1} \& \underline{\alpha_2}$ only stipulates the performance of actions α_1 and α_2 (corresponding semantical α_1 and α_2), but X is free to perform any other set of elementary actions simultaneous with α_1 and α_2.

It is important to note that collective event $X : \beta$ is not an event that is performed if and only if every actor in group X performs the action β. A group event $X : \beta$ can be performed if only a subgroup of X (maybe one person or the whole group together) has performed the action β. Thus, with a deontic dynamic logic of e.g. Meyer (cf. [18]), we could express, on the one hand, that group X as a whole has the responsibility to perform action β, even if the action is performed by a subgroup of X, which cannot be represented with the 'brings it about' operator. On the other hand, we can model the fact that if the group as a whole performs an action, none of its members performs that action, for instance, when a construction company builds a house. For the formal semantics of events we refer to [22].

In general, a group can only do something if some members of the group do something, and it is plausible to assume that the elementary actions of a group are constituted, in some way or other, by the elementary actions of the members of the group. For instance, if a member performs an elementary action a, the group also performs this action. However, the group is not restricted to performing the elementary actions that are performed by the individual members of the group, since a group can perform an elementary action that cannot be performed by a single individual. For instance, 'to lift a stone of 500 lbs'.

3.3 A logic of events and norms

In [22], it is shown how the event expressions can be mapped directly to (deontic) dynamic logic expressions. Since, the event expressions are not propositions, we add a special construct $OCCUR(\alpha)$ to record the occurrence (happening) of an event. The meaning of $OCCUR(\alpha)$ is 'the present state is actually reached by the occurrence of α'. Suppose α stands for $X : \beta$, then $OCCUR(X : \beta)$ stands for 'the present state is actually reached by the performance of β by X. The definition of *OCCUR* is the same as the one for *PREV* in [4]. The following validities hold for *OCCUR*:

- $[\alpha]OCCUR(\alpha)$, meaning that $OCCUR(\alpha)$ becomes true when the event α has just been performed.
- $OCCUR(\overline{\alpha}) \leftrightarrow \neg OCCUR(\alpha)$
- $OCCUR(\alpha_1) \vee OCCUR(\alpha_2) \leftrightarrow OCCUR(\alpha_1 \cup` \alpha_2)$
- $OCCUR(\alpha_1) \wedge OCCUR(\alpha_2) \leftrightarrow OCCUR(\alpha_1 \cap` \alpha_2)$
- $\neg OCCUR(X : \mathbf{fail})$, meaning that a group of agents cannot perform an impossible action.
- $OCCUR(X : \mathbf{any})$

From the semantics of events we can derive the following validities considering positive actions $\gamma \in Act_p$:

1. $OCCUR(X : \gamma) \rightarrow OCCUR(X \cup Y : \gamma)$
2. $OCCUR(X \cup Y : \overline{\gamma}) \rightarrow OCCUR(X : \overline{\gamma})$

If some agents in a group X perform action γ, and other actors in X do not perform γ, then this does not mean that X performs action $\gamma \& \overline{\gamma}$. X performs action γ if and only if some subgroup of X performs γ, and X does not perform γ if and only if no subgroup of X (thus, also no actor of X) performs action γ. Thus, a group X, just like individuals, cannot perform an impossible action $\beta \& \overline{\beta}$. Using the above event expressions and construct *OCCUR* we now introduce the deontic operators over events as follows:

$$O(\alpha) \equiv [X : \mathbf{any}]O(OCCUR(\alpha))$$
$$F(\alpha) \equiv O(\overline{\alpha})$$
$$P(\alpha) \equiv \neg F(\alpha)$$

So, α is obligated if, whatever is performed now, it will be true immediately afterwards that α just previously was obligated. Suppose α stands for $Y : \beta$, this means that if Y performs $\overline{\beta}$, Y reaches a state where violation occurs, indicated by the fact that in that state both $O(OCCUR(Y : \beta))$ and $OCCUR(Y : \overline{\beta})$ hold true. Since, the formula $[\alpha]OCCUR(\alpha)$ is valid it holds that

if $O(\alpha)$ then $[\overline{\alpha}](OCCUR(\overline{\alpha}) \wedge O(OCCUR(\alpha)))$

This corresponds with $O(\alpha) \equiv [\overline{\alpha}]$Violation. Here it suffices to note that e.g. the claim that the event denoted by α is forbidden is equated with the fact that the resulting state is not ideal (i.e. is in violation), because $OCCUR(\alpha)$ holds in that state while $OCCUR(\alpha)$ holds in the ideal states alternative to that state.

4. Collective obligations

Although obligations most often are aimed at individuals, like in the statutes of law, obligations can also be aimed at a group. A collective obligation is different from a restricted general obligation (indicating that for every person in a group the obligation holds). This can be seen easily from the following example, taken from Rescher ([21]):

John and Paul are obliged that the table is moved across the room.

If John alone accomplishes that the table is moved, then the group (John and Paul) satisfies the norm, i.e., the obligation that the table is moved. This can now easily be represented. From

$$O(OCCUR(\{i; j\} : \beta) \wedge OCCUR(\{i\} : \beta),$$

where i and j stands for John and Paul respectively, and β for the positive action 'to move the table across the room', directly follows

$$O(OCCUR(\{i; j\} : \beta)) \wedge OCCUR(\{i; j\} : \beta),$$

indicating that the obligation is fulfilled. It does not follow from the obligation that Paul would have to help John. From a collective obligation $O(X : \beta)$ it does not follow that every agent of X has to perform β. Thus, $O(X : \beta)$ is not equivalent to $\forall_{i\in X}O(\{i\} : \beta)$ (the restricted general obligation).

If we want to emphasise that i and j are both 'essential' group-components to fulfil an obligation, then we can formalise this as follows:

$$O(OCCUR(\{i; j\} : \beta)) \wedge F(OCCUR(\{i\} : \beta)) \wedge$$

$$F(OCCUR(\{j\} : \beta)) \quad (2)$$

We can regard (2) as a definition of genuine group obligation or cooperative obligation (cf. [8]). The theory can easily be extended with the notions of 'counts as' and 'quality' introduced in section 2. Consider the submission of a research grant proposal of subsection 2.3. This can then be represented as

$$OCCUR(\{h\} \text{ acting as an adm.-of } s : \beta_1)\ )\ s$$

$$OCCUR(s \text{ acting as himself} : \beta_2); \quad (3)$$

where β_1 stands for the action 'to sign the form' and β_2 for 'to produce the grant proposal'. Exploration of these notions and further extensions are issues of future research. An extension could be the following rule:

$$\frac{OCCUR(X : \beta_1)\ ) \Rightarrow_s OCCUR(Y : \beta_2)}{F(OCCUR(Y : \beta_2)) \rightarrow F(OCCUR(X : \beta_1))}$$

meaning that 'if for Y something is forbidden, then the action β_1 performed by X which counts as the action β_2 performed by Y is also forbidden. This seems intuitively correct in an institutionalised framework, and which give us new expressive power. Consider again the grant proposal example. Then we can derive (with the help of the rule and (3))

$$F(OCCUR(\{h\} \text{ acting as an adm.-of } s : \beta_1))$$

from $F(OCCUR(s \text{ acting as himself} : \beta_2))$.

5. Conclusions

In this paper, we have formalised the concept of groups of agents in dynamic deontic logic, which allows us to specify that a group is obliged, prohibited or permitted to perform an action. The advantage of the dynamic variant above the action modality E_i is that the ambiguity of the interpretation of the actions performed by agents disappears. We have shown that sometimes a group X fulfils his obligation if only some subgroup performs the obligated action, and sometimes if every subgroup has to perform the action, which can smoothly be represented in the developed theory.

In our interpretation of $O(X : \beta)$ (and also in the notions of 'counts as' and 'quality'), we consider in fact the groups to be separate 'institutionalised agents' as in the theory of relativised deontic modalities concerning norms for an individual, since now every group stands on its own, like agents. Such a group will be considered as a communicative, cooperative and coordinated group. A consequence of this interpretation is that we do not gain an understanding of the collectivity of the obligation concerning the relation amongst the individuals and the relation between the individuals (or subgroups) and their collective obligation to accomplish some goal. The transformation of collective obligation to the members happens automatically, by magic. The notion of commitment is lacking here as a mediator of such transformation (see [3]) to express issues like delegation, adaptation, intention, responsibility, etc., which constitutes the theory of collective action in a narrower sense. This is one of the complex and interesting issues in the logical theory of collective agency. Some researchers have already initiated this issue (see e.g. [5], [23], [24]), but these works are far from being finished.

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