

Considering Collectives: Roles, Members and Goals

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Abstract. There is a growing need across many disciplines to be able to model and reason about groups of individuals (i.e., collectives) resulting in an increased interest within the field of ontology. In previous work a taxonomy of collectives was presented that allowed a user to distinguish the different types of collectives. The taxonomy classified each collective according to five criteria: membership, coherence, location, differentiation of role and depth. However the taxonomy is found to be lacking in terms of: addressing how changes in membership affect the identity of the collective, recognising the importance of role, and its sensitivity to temporal scope. Drawing from existing research this paper discusses how a collective can only be sufficiently characterised by considering the relationship between a collective, its members, the roles that they play and the coherence criteria (i.e., the reason that we consider a phenomenon to be a collective). Preliminary updates are suggested for the taxonomy that will allow collectives to be sufficiently characterised.

Keywords. collective, role, membership

1. Introduction

There is an increased need to be able to represent and model collectives (i.e., groups of individuals) within fields such as bioinformatics, [1,2,3,4], biomedicine [5] and social reality [6,7,8]. Membership is clearly a key property of these phenomena [6,9]; without the possibility of individual members the concept of a collective would not be possible. However, the relations between a collective, membership and role are a key issue when deciding how to model and represent these phenomena.

Wood and Galton [9] present a taxonomy of collectives designed to allow a user to distinguish the different types of collectives; this taxonomy is extended in [10]. The taxonomy classifies each collective according to five criteria: membership, coherence, location, differentiation of role and depth. However the taxonomy has been found lacking particularly in areas relating to the identity of a collective. In [9] a collective is defined as a concrete particular. At any one time a set of individual continuant entities is considered to be the set of members at that time. Wood and Galton state that this set does not identify the collective due to the possibility of a change in membership not affecting the identity of the collective and that a set is an abstraction and not, like the collective, a concrete particular. A unary predicate F is used to express a membership-defining property. The possible range of membership-defining properties is not defined and left as further work.

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Variable membership is deemed an important property of many collectives. Therefore, the members of a collective can be defined extensionally or intensionally with the collective having a lifespan over which it endures. If defined in intension, the members of the collective all satisfy a *unifying criterion*, referred to as the *source of their collectivity*. The effect of membership change on the identity of the collective is not really addressed in [9]. If a collective is classified as having constant membership, it implies that the collective would cease to exist once the membership of one of the individuals is terminated. However, this seems insufficient and only deals with a subset of collectives. The possibility of variable membership, and in particular canonical membership, led to the distinction between robust and constant cardinality being included in the taxonomy. This distinction is difficult to apply. At what stage is the collective considered so damaged by a loss of members that it is no longer considered as the original collective (i.e., the identity of the collective changes)?

The taxonomy is also found lacking when highlighting the importance of roles within some collectives. The existing taxonomy classifies a collective according to whether a role structure exists and, if so, what that structure is. However, this does not really account for those collectives that depend on a number of roles being fulfilled in order to exist (e.g., a cockpit crew, a committee). For example, a string quartet does not rely on having any four individuals as members; a first and second violist in addition to a viola player and a cellist are required. Arrow and McGrath [6] question the affect of membership and role change on the identity of a group. If a group slowly changes over time at what point, if any, is it ever considered to form a new group? An example of a jazz quartet is given, which are observed at two gigs. Between gigs the musicians change the instrument that they play; Arrow and McGrath ask whether this role change has resulted in a new group.

In addition to the problems with identity outlined above the taxonomy is sensitive to temporal scope with the period of existence being considered for a collective affecting the properties that can be assigned to it. For example, a committee, orchestra or sports team are classified differently in terms of role structure, membership and location when considering the entire existence of a collective to one particular meeting. Wood and Galton suggest no method to combine classifications for several particular events within a collective's lifetime or identify the collectives that this was possible for. This sensitivity to temporal scope results in a collective's classification possibly comprising several classifications with each classification representing a distinct phase of its existence. The possible temporal patterns of these classifications have not been examined. These patterns could reveal important information about the collective, including information relating to its identity [11] but this cannot be explicitly specified in the taxonomy.

This paper analyses existing research and discusses how the subtle relationship that exists between a collective, its members, the roles that they play and the coherence criteria (i.e., the reason that we consider a phenomenon to be a collective) must be considered if these phenomena are to be accurately modelled. Preliminary updates are suggested for the taxonomy that will allow collectives to be sufficiently characterised.

An extended literature review is given in section 2 followed by a discussion of how some of the ideas can be drawn together to address the problems that have been outlined (section 3). A suggestion is made on how the taxonomy can be updated to reflect the work in section 4. The work reported here is preliminary and the paper concludes

with a discussion of how it must be taken further to produce a complete and formalised taxonomy of collectives (section 5).

2. Relevant Literature

Unlike mathematical set-membership, the *member-collective* relation allows a member to be considered as a part of a collective [12,9]. This paper will focus on research that deals with the relationships that exists between a collective, its members, the roles that the members play and the task associated with the collective. The literature review is split into the following topics to aid readability: definition of role, the importance of roles within collective, the importance of considering the collective's task and the temporal scope of the collective.

2.1. Definition of Role

The concept of roles, and how they should be represented, has been discussed in a number of fields including knowledge representation, knowledge engineering, object-orientated and conceptual modelling, multi-agent systems and sociology and philosophy [13]. These disciplines share some common characteristics when defining the term *role*. Masolo *et al.* present a literature review of the key points addressed within each of the fields with the aim of producing a 'general formal framework' to aid the development of a 'foundational ontology of social entities'. Four 'characteristics of social roles' are extracted from the literature review namely that they are: properties, anti-rigid with dynamic properties, relational and linked to contexts. Five dynamic properties are identified following the work of Steimann [14]: different roles can be simultaneously played by an entity; the same role can be played simultaneously or at different times by different entities (i.e., they do not depend on their players); an entity can switch roles; and, the order of roles that an entity can adopt or release may be subject to constraints.

Boella and van der Torre [8] extends the work presented within [13] and propose a foundational ontology of the social concepts of organisations and the roles that structure them. When building their ontology they consider the relationship between institutions, organisations and the roles with objects and against. Boella and van der Torre distinguish between the terms *role* and *social role* is made. A role within description logics is 'synonymous of an arbitrary binary relation (often a function) used to characterise the structure of a concept'. This is not the same as a social role. Boella and van der Torre consider roles to be components of organizations, which are social concepts only existing because of the collectively accepted descriptions that define them and, therefore, roles are considered social entities that only exist because of social conventions. Roles are properties which can be played by different agents and are considered founded and anti-rigid. Since these social roles have a dynamic behaviour, they must have a temporal component. This is a point that is also made by Bottazzi *et al.* [1]. Like Masolo *et al.* Boella and van der Torre note that roles can be defined as a basis of a relation where specific properties can characterise the arguments.

2.2. *The Importance of Roles for Collectives*

Roles can be used to identify and distinguish different collectives due to: the ways in which they structure the collective, the link that exists between the task that the collective is trying to achieve, or the effect that they have on the behaviour of the members.

Guizzardi [3] focuses on how collectives can be properly represented including the relevant part-whole relations. Part of a series looking at part-whole relations, this paper focuses on an ontological analysis of the *member-collective* and *subcollective-collective* relations. Four distinct ontological types of parthood relation have been outlined in previous work: *subquantity-quantity*, *member-collective*, *subcollective-collective* and *component-functional-complex*. Member-collective allows a collective entity to be modelled where all parts play an equal role with respect to the whole (e.g., the trees in a forest). Sub-collectives gives further structure to collectives. component-functional complex allow entities to be modelled where a different roles are played by the parts with respect to the whole. Some wholes may have parts that are all essential (inseparable), some may have only some of their parts that are essential and others will have no essential (separable) parts. A collective is distinguished from a functional complex because the former's structure is uniform with all members playing the same role with respect to the whole (e.g., the trees within a forest); the latter has a complex and heterogeneous structure with the parts playing a variety of roles. An example given is a fleet of ships. If each ship only plays the role of member, the fleet is deemed to be a collective; if the ships had specialist roles (e.g., leader, defence ship), it would be considered as a functional complex. Collections need not be defined by their members but must have a unifying relation to characterise them.

Bottazzi *et al* [1] present an ontological analysis of 'intentional collectives' in order to address the concept of collective intentionality. Within D&S (Descriptions and Situations Ontology) a role is a concept, 'a social object that is defined by a description'. Roles can be used to specialise other roles. A distinction is made between collections and collectives. The former is constituted by its members but not necessarily defined in extension. The members must satisfy an identity criterion. Collections require a social object that provides the unity criterion. The members of a collection are all classified by the same role. The role is shared and acts as a 'covering relation towards the collection'. This is similar to the ideas of granular parts that each 'play the same role within the collective' as presented by Rector *et al.* [5]. Within [1] covering roles can be constrained by parameters to form a *Parameterized Collection* (e.g., a crowd of people). *Organized Collections* are characterised by further roles. In contrast a collective is a collection of agents that are unified by a description and characterised/covered by a role. It is suggested that you could have a hierarchy of roles leading to a more varied typology of intentional collectives but this is left as further work.

Not all groups will have relevant roles or be structured by roles. Within [15] Boella and van der Torre present an ontology which represents and reasons about social reality. A distinction is made between groups, organisations and normative systems. A group is a group of agents that coordinate their behaviour to achieve shared goals. An organisation is a social construction that allows members to coordinate their behaviour. Organisations are structured into sub organisations and roles that are assigned to the agents. A normative system is a social construction that is used by agents to achieve a 'certain social order'. Unlike an organisation where roles characterises its structure, a group is

not structured according to roles and, therefore, does not form a normative system. Smith [16] notes that within some object aggregates, the parts will satisfy further conditions, such as an organisation where the members will have specific types of roles.

Organisation could be considered a form of collective and there exist many ontologies that focus on organisations [6,15,7,8]. Van de Ven focuses on the 'inter-organisational relationships (IR)' that exists between organisations. IRs can be studied from lots of different perspectives but Van de Ven chooses to consider a social action system due to the properties of the collective behaviour that is exhibited. These systems can be thought of as units with identities that are unique from their members (just like a collective). The division of functions and tasks among members can result in specialist roles being adopted that will govern their behaviour. Organisations do not always depend on those that play the roles, 'the dependences and the relations between roles are fundamental' [17]. A role can also describe the behaviour that is expected of an agent by an organisation [15,1,8].

Roles can have a key impact on the overall goals and activities of an individual or an organisation. Berne and Sheats [18] present a classification of member roles that indicate three groupings: (1) group task roles, (2) group building and maintenance roles and (3) individual roles. (1) relates to any roles that are needed to achieve the group's task or goal. (2) enable the group to function efficiently. (3) do not relate to the group's task but the individuals themselves.

2.3. *The Importance of Considering the Collective's Task*

Arrow and McGrath [6] focus on the member dynamics of the work groups that exist in an organisation setting and propose a theoretical framework to deal with the phenomenon. A group is defined as a 'recurrent pattern of dynamic relations among people, tools and tasks'. The relationships between these components can be used to describe how 'groupy' the system is. Distinctions are made between different work groups with three types outlined: task force, crews and teams. Task forces are put together to address a particular project or task and will disband once this has been achieved. Within a team each member will have a specific skill set that will allow the organisation to assign relevant projects and tasks. Examples given include a crime investigation team or a management strategic planning team. A crew is assigned to a set of tools to achieve a specific goal when necessary. Examples given are a cockpit crew or a shift of workers on a production line. Relations are defined that allow how 'groupy' the system is to be established. Two are relevant to this paper: *group-member* and *member-task*. The former allows individuals to consider themselves as part of the group. The latter is what is shared to achieve the group's task by cooperative activity. Although the definition given by Arrow and McGrath link members, tools and tasks they still believe that it is the members that are the most important and what defines the group. They note that a changing the task for a group but not their members would allow an outsider to identify the same group but with a different project. However, if the members were changed, and not the task, the group would not be considered the same.

Collectives are a group of intentional agents, physical or social objects that can conceive descriptions, within the ontology presented by Bottazzi *et al.* [1]. The collective is formed when a 'unifying plan' is created by the agents, The collective will be characterised by this plan and it is what unifies and characterises the collective.

2.4. *Temporal Scope of Collective*

The temporal scope of the collective refers to its existence over time. This section will look at research that addresses when changes in the membership or goal of a collective might affect the identity and existence of the collective.

Arrow and McGrath [6] refer to the membership dynamics of a group, which is defined as ‘patterns of member change and continuity over time’. These changes could relate to members, group identity or the structure of roles or status within a group. The impact of membership changes will depend on the type of group that is being considered. Members could be full, transient (e.g., visitors) or marginal (e.g., Rookies). Arrow and McGrath [6] suggest that the proportion of members that have been involved in the change could help identify whether or not a new group has been formed. A distinction is made between permanent and temporary groups with the use of *standing* and *acting* groups. When a group is defined by an interaction, the group will cease to exist once that interaction has finished. However, some groups can be considered to endure between interactions; these groups are referred to as standing groups. When interacting, a group is referred to be in ‘a session’. A standing group can operate even when all members are not present. An acting group is all the members involved in a particular session and could include transient members (i.e., visitors) who are not members of the standing group. Some groups will have a standing group, an acting group or both. ‘Standing membership in an organisation pool’ is also discussed where the members can be chosen from within a certain organisation or department. The ‘standing pool’ comprises all of the individuals that could fill a position within a group. For example, the pilot within a crew will be a pilot employed by a particular airline.

The distinction made by Arrow and McGrath [6] between task forces, crews and teams appear to consider whether a group endures when not on a particular project. However, groups can evolve (e.g., a task force can become a team if it lasts after the project has been completed). Within each of these three types of group the members could fulfil certain roles or possess a certain skill set that allows them to be a member. Berne and Sheats [18] note that different tasks may require different roles but that the role types that are required may depend on the stage of the group (e.g., if it is newly formed or near to termination). This suggests the possibility of the role relations evolving during the existence of the collective, just like the membership relation (i.e., allowing for variable membership).

Schulz *et al.* [4] note that biological continuants can gain and lose parts whilst enduring through time. Therefore, a temporal component is added to part-of to indicate that a part is related to the whole at time t . A number of relations are proposed, which is of relevance to this paper including *possible-part-of*, *temporary-part-of* and *historic-part-of*. Temporary-part-of and permanent-part of is used to distinguish between those parts that are always part of the whole and those that share the relation at certain instances of the whole’s lifetime. The relation between these two part-of relations allows the relation historic-part-of to be defined, which will occur when temporary-part-of is true but permanent-part-of is false. They do not extend this to allow for future hypotheses. It is also noted that the functionality of a whole is not always affected when an individual part dies or becomes disfunctional.

Bittner *et al.* note that individuals, universal and collections have different temporal properties [19]. A collection is identified through its members and therefore can-

not gain or lose parts. The different relations between the three entities are considered in two groups according to their dependence on time. Time-dependent relations include: extension-of that relates collections and universals, partition-of and sums-up-to which relate collection to individuals, and instance-of that relates individuals and universals. member-of which relates individuals to collections, sub-collection-of that relates collections to other collections and universal-part-of and sub-universal-of that relate universals to universals are all considered to be time-independent.

The problems of representing and effectively using part-whole relations in domain ontologies are noted by Artale *et al.* [20]. Within [20], temporal logic is used to address some of these challenges allowing essential and immutable parts and wholes to be considered in addition to mandatory parts and wholes. Cardinality constraints are not sufficient to distinguish between essential, mandatory and immutable parts and wholes; it is for this reason that they adopt temporal logic. The distinction between essential and mandatory parts can be compared to specific and generic dependence. If a part is essential the whole is specifically dependent on that part. If a part is mandatory, the whole is generically dependent on it (the part must be present but can be replaced with different instances of it). Immutable parts are a 'weaker' form of essentiality allowing for non-rigid wholes. They are temporally bound by specific dependence but not throughout the whole lifetime of the individual; they can be referred to as 'conditionally essential parts'.

The concept of rigid and anti-rigid classes can be used to capture the distinction between immutable and essential parts and wholes [20]. Rigid and anti-rigid classes allow the strength of the relation between a whole and a class that it is described by. Therefore, essential parts relate to the 'properties of whole being member of rigid class'; immutable parts 'the properties of whole being member of anti-rigid class'. A reference is made to the classification proposed by Guarino and Welty [21] that classifies roles. The formalism proposed by Artale *et al.* distinguishes between generic dependence (i.e., a mandatory part), unconditional specific dependence (i.e., an essential part) and conditional specific dependence (i.e., an immutable or conditionally essential part) [20].

Roles have a dynamic behaviour and, therefore, a temporal relation [1,8,13]. Roles can be linked to an entity participating in an event (i.e., participation roles) [22]; membership could be considered as a form of participation (i.e., participating in achieving the overall goal). However, as noted by Masolo *et al.*, a role can endure when the entity is not participating; an example given is that a musician is still considered to be a musician when not performing [13].

Within [20] relations can be scheduled, active, suspended or disabled. The instantiation but not the membership are known within a scheduled relation. If a part is currently part of whole it is referred to as being active. Suspended relations are those that are temporarily inactive. A disabled relation allows those relations to be modelled that have expired and cannot be used again. An example given of a disabled relation is that of a donor heart after it has been transplanted; the relation between the donor and the heart would become disabled at the point of the transplant.

3. Discussion

The existing taxonomy is lacking in three areas: addressing how changes in membership affect the identity of the collective, recognising the importance of role, and its sensitivity

to temporal scope. This section discusses how some of the concepts highlighted in section 2 could be used to address these issues.

Under the previous taxonomy collectives can be defined extensionally or intensionally [9]. The former are defined by their members; a loss of at least one member would result in the collective ceasing to exist. The latter can be further classified according to whether their members can vary and, if they can, a cardinality constraint introduced to specify the minimum number of members needed to survive. The distinction between robust and constant cardinality is to allow for canonical membership but is difficult to apply. Unless the cardinality of members depletes below the threshold, the criterion does not fully specify when a change in membership would result in a new collective being formed. The use of a percentage of membership change to deem whether or not a new group has been formed, as suggested by Arrow and McGrath [6], seems insufficient and subjective.

It is clear that variable membership is an important feature of some collectives. The members of these collectives can come and go, or be replaced, without affecting its identity. Consider pop groups like KISS and the Sugababes who have both changed membership since they started but are still referred to by their original names. Sports teams and musical groups continue to change membership but the overall collective's identity remains intact. One could refer to a set of members from a particular time in the collective's history (e.g., Saracens F.C. season 2015/16) but, as already noted, these sets do not equate to the identity of the collective [9]. These examples appear to highlight that some collectives are not dependant on its members. At some point in its lifetime a collective will need to have members to have been considered as a collective but the question arises as to whether the identity of the collective is related to those members or something else?

A collective is formed once the unifying, or coherence, criterion for that collective becomes active or is deemed to be a suitable criteria. For example, one may only consider the items in my handbag as a collective once I have deemed them to be one. In comparison, the Bournemouth Symphony Orchestra became a collective once it was founded and it is at this point that the unifying criterion would become active. With the examples given, where a change of membership does not affect the identity of the collective, the source of the coherence (i.e., the reason we consider them to be a collective), is collective purpose. If the source of coherence for a collective relates to a goal will a change in membership ever affect the collective's identity? Some collectives will have no task to complete or common goal. These could be considered collectives whose coherence is due to an external cause in the original taxonomy. Other collectives do have a task to complete, or goal, either as individual members (e.g., a queue) or as a collective (e.g., an orchestra or a sports team). In the original taxonomy, these would be considered collectives whose coherence is due to purpose.

The goal of a collective may be related to the roles that the members play [6,18]. Clearly a role must be fulfilled by an individual, or group of individuals, and therefore, one could argue, that the collective needs these members to exist. However, the key difference is that the collective does not rely on specific individuals to exist; they rely on individuals satisfying specific role types. Some collectives will only have participation or covering roles (i.e., 'being a member'). Other collectives may be dependant on the roles that are played by their members. These roles may require certain skills or qualifications that are necessary for the task. For example, the crew of a flight will need to have certain positions filled where each position requires a qualification or skill set. A string quartet

requires four roles to be fulfilled: first violin, second violin, viola and cello. Therefore, the members will need to be able to fulfil one of these positions. A member of the string quartet could be replaced but only if a suitable candidate is found. Members can be described as being essential, mutable or immutable. Is there a way that this concept could be applied to the role-collective relation? Roles are anti-rigid [13,21]. Artale *et al.* would relate this to an immutable part when distinguishing between generic dependence (i.e., a mandatory part), unconditional specific dependence (i.e., an essential part) and conditional specific dependence (i.e., an immutable or conditionally essential part). It would appear that the identity of the collective will be affected in the cases if the achievement of the task is linked to its members or the roles (i.e., it needs specific members or roles in order to satisfy the goal).

Often replacing the members in a collective that depends on role types will not affect the identity of the collective. A football team frequently undergoes changes in membership but the identity of the team remains. However, sometimes the identity will be affected. Consider the band Queen. They have begun to tour again but with a different lead singer. Instead of keeping the original name they have updated it to include the name of the new lead singer, Queen and Adam Lambert. Note, the new name does not fully reflect the loss of one of the original members. This example suggests that sometimes it is not just a qualification that is needed for a certain role to be fulfilled but a specific individual.

As noted in the literature review, different roles can be played simultaneously by different entities. The same entity could play multiple roles simultaneously or at different stages in the lifetime of the collective. Therefore, using roles to define a collective could be difficult. It is clear that the temporal component of the role-member relation is important. If using the role structure to define a collective, what should happen if that role structure changes? Would it then become a new collective? Or is noting that certain roles are required, that can be fluid between members, be sufficient? What happens if the roles required by the collective evolve as suggested by [18]? These questions are discussed further in section 5.

The possibly of adding a temporal component to the collective-member relation (i.e., to determine if it is active or not) could help decompose a collective's existence into key events (e.g., the term *session* is used by Arrow and McGrath [6]). It could also help model current members and historic members of a collective. During a session where members are actively meeting to achieve the collective's goal, the relationship between member and collective would be considered active. For example, during a committee hearing, orchestra performance or a football match. When not being an active member the relation would be considered as suspended. Once the member is considered to have left the collective, the relationship becomes disabled. Disabled membership relations would help identify historical members of the collective (e.g., the IAOA Executive Council of 2010). Scheduled relationships could be useful if it is known that an individual will become a member. For example, when a child is notified that they have a place at their next school or when an individual successfully applies for a new job. It could be difficult to establish when a relation is suspended and when it is disabled. If a collective is still considered to exist and an individual is considered to be a member then the relationship should be suspended. It should only be disabled once the individual is no longer considered a member or the collective has ceased to exist. The distinction between active, suspended and

disabled seems similar to that of possible-part-of, temporary-part-of and historic-part-of as suggested by [4].

Whether or not a collective's existence comprises several sessions can reveal important information about a collective including information that will help identify it [11]. The use of active and standing groups by Arrow and McGrath [6] could help overcome the existing taxonomy's sensitivity to temporal scope. The possibility of whether a collective could have an acting group, standing group or both could help distinguish the different types of collective. If a standing group is possible it is clear that the collective's existence would consist of a series of events and, therefore, several classifications. These types of collective could then be classified further according to temporal pattern of these events (e.g., their regularity or if they occur in a certain sequence).

Drawing on all of the existing literature, it would appear that a collective can be characterised by the relationship between its members, the roles that they play and the presence of task that they are trying to complete, where the task relates to the unity criterion as described in [9]. All of these relations must be considered if the phenomena are to be accurately modelled.

4. Proposed Solution

This section outlines preliminary suggestions of how the ideas within section 3 could be brought together to update the existing taxonomy of collectives. The identity of extensionally defined collectives is clear. They are defined by their members; the collective will cease to exist when at least one the members leaves. Therefore, the collectives that appear most relevant to this paper are those that have been defined intensionally. For these collectives the relationship between members, roles and tasks must be considered in more detail. The following relationships are of interest and seem to be important in characterising the collective: *collective-member*, *collective-task*, *role-member* and *role-task*. The preliminary work presented here considers the first three relations.

4.1. *Collective-member and Role-member*

The relations between a collective, its members and the roles that they play can be addressed by updating the membership criterion in the existing taxonomy.

It is clear that the original distinctions made in the membership criterion of the taxonomy are insufficient in establishing what defines the collective. The criterion was concerned with both the identity and cardinality of the members. It is clear that the identity of the collective could depend on roles or members. An update of the membership criterion in the taxonomy should reflect this. The previous taxonomy initially distinguished between constant and variable membership. If members could vary, the collective was further characterised according to whether the cardinality was constant or variable. Constant cardinality was characterised further into robust and weak. If considered to have variable cardinality the minimum number of members that the collective could survive was specified (i.e., 0 or 1). The cardinality distinctions could identify when a collective ceases to exist (i.e., when the number of members go below a threshold) but now appear subjective and difficult to apply.

In the updated taxonomy the initial distinction is between extensionally and intensionally defined collectives. If extensionally defined, the collective must have a specific

set of members to survive. The members of an intensionally defined collective all satisfy a unity criterion and can be further classified according to whether or not the collective is dependent on certain roles being fulfilled. Collectives that are not dependent on roles, such as a crowd, can have any members that satisfy the unity criterion; each member simply has the role 'member'. If the collective is dependent on roles, it can be further classified according to the member-role relation. A collective could be dependent on a set of roles but those roles could be fulfilled by any individual. In contrast the members may need to satisfy a constraint or qualification in order to fulfil those roles (e.g., a string quartet). The distinction between constrained and unconstrained roles could be difficult to apply but have been included at this preliminary stage for further investigation in future work. For some collectives it would appear that roles must be fulfilled by specific people (e.g., the current touring version of Queen). One could argue that these collectives are defined extensionally but this would suggest that the loss of a member would result in the collective ceasing to exist. This does not seem to be true for some collectives and resulted in [M2.2.2] being included for completeness (even though it may only be true for a very small number of collectives). Collectives that depend on at least one role being fulfilled (e.g., a Jury needing a foreman) should be classified as being dependent on roles. This would allow the essential roles to be included with the remaining members having only covering roles. Further investigation may reveal that the taxonomy criterion should be extended to differentiate collectives which depend on all members fulfilling roles, where none are covering roles, and those collectives where some members would take covering roles.

M1 Extensionally defined collective

M2 Intensionally defined collective

M2.1 Collective not dependent on roles

M2.2 Collective dependent on roles

M2.2.1 Collective generically dependent on roles

M2.2.2 Collective specifically dependent on members

M2.2.3 Roles are constrained by qualifications

The update does not account for the structure of the roles that the collective depends on. This could be characterised, to a degree, by the differentiation of role criterion in the existing taxonomy but the difficulties outlined in section 3 of defining a collective using roles remain unaddressed and is left for future work.

4.2. *Collective-task*

The collective-task relation should examine the goal of the collective. The coherence criterion in the original taxonomy identifies whether or not the collective has come together due to purpose or cause and classifies further according to whether these are external or internal. External causes could be purely causal or a cause arising from an external purpose. External purpose occurs in purely fiat collectives. If the coherence is due to internal purpose, that purpose could be individual or collective. The previous discussion has shown that these distinctions are still useful since the collectives that we are interesting in with regards to this paper appear to arise from internal purposes, either individual or collective. However, an additional criterion would be useful that examines the whether

or not the completion of the task results in more than one session thus indicating if there may be periods where the members are not actively participating in the collective.

The additional criterion, which will initially be referred to as *I* criterion examines the temporal component of the interactions that a collective can take part in and whether or not the collective persists for multiple interactions. The term *session* could be used to refer to a period of time when members of a collective are actively participating to achieve the goal of the collective. The distinction between active, suspended and disabled can be used to determine whether or not members are taking place in these sessions. If the collective does persist over more than one session, the temporal pattern of those sessions could be examined. Examples are needed to establish the temporal patterns that are possible.

- I1 Task completed in a single session.
- I2 Task completed over multiple sessions.
 - I2.1 Interactions occur irregularly.
 - I2.2 Interactions occur regularly.

The preliminary update, as suggested above, does not denote whether all individuals need to be present for each interaction. This will need further consideration. The inclusion of this new criterion will make it easier for collectives to be classified over longer periods. Clarifications were needed in the original taxonomy for collectives such as orchestras and football teams to understand whether or not they were in a meeting (e.g., instead of an orchestra or a football team, classifications were given for an orchestra during a performance or a football team during a match). These specific sessions could still be classified under the updated taxonomy, to understand how they function when meeting, but the new criterion allows the entire lifetime of the collective to be considered with less ambiguity. When considering entire existence the location criterion may need to be omitted since this depends on whether or not they are in session.

When added to the existing taxonomy, the updated membership criterion and the new *I* criterion, results in a taxonomy comprising six criteria. It does not seem sensible to classify collectives according to the *I* criterion if they have been defined extensionally (i.e., *M1*) since it is difficult to consider these collectives as task orientated. It is likely that the additional *I* criterion is only appropriate for collectives whose coherence is due to purpose (individual or collective). There appears to be no other ways in which the two new criteria cannot be combined. However, further application of the new taxonomy to existing problems may identify impossible combinations.

5. Further Work

This paper has presented a review of existing literature and showed how it can be used to update and improve the existing taxonomy of collectives to ensure that the subtle differences between the different types of collective can be recognised, particularly the relationship between the collective, its members, the roles that they play and the collective's coherence criterion. The work is in its preliminary stage and further work is needed to produce a completed formalised taxonomy of collectives.

- The updated membership criterion reflects that some collectives are dependent on members whereas some are dependent on role (i.e., the collective-member

and role-member relations) and that some roles are constrained since only certain people can fulfil them (i.e., those with the necessary skill set or qualification). A distinction must be added to the taxonomy that considers whether or not the roles relate to the goal of the collective (i.e., the role-task relation). If they do then a change in roles is more likely to result in the formation of a new collective. If not, then the collective is not dependent on the roles. It could be argued that the constraint on roles within the membership criterion suggests a close link with the task thus representing the role-task relation but this needs further consideration.

- The difficulties of representing roles in terms of their fluidity amongst members needs to be addressed (e.g., can the roles be played by different individuals at different times, or can the required roles change as the collective evolves without affecting the identity of the collective). The difficulties outlined in section 3 of defining a collective using roles must also be addressed.
- The interactions of a collective, referred to as sessions could be considered as events within a collective's existence. Further work is needed to see if this would be a more useful way of considering these interactions. Examples also need to be gathered to examine the possible temporal patterns of the interactions.
- The movement of a collective can be very important and is not really addressed by the existing taxonomy or the work within this paper. Ongoing work is trying to address this problem.
- Further work is need to understand if the proposed solution does sufficiently capture the distinctions between the different collectives. Investigations are also being carried out to see how much of this information is apparent when mining for collectives in spatiotemporal datasets.
- Once completed the updated taxonomy should be formalised.

6. Conclusions

In previous work a taxonomy of collectives was presented that allowed a user to distinguish the different types of collective. However the taxonomy was found lacking in terms of: addressing how changes in membership affect the identity of the collective, recognising the importance of role, and its sensitivity to temporal scope. An extended literature review has been presented from which it would appear that a collective can only be sufficiently characterised by considering the relationship between its members, the roles that they play and the presence of task that they are trying to complete, where the task relates to the unity criterion as described in [9]. A discussion of how the taxonomy might be updated accordingly is presented with preliminary suggestions given. The update sees a replacement of the previous membership criterion and an addition of a sixth criterion to the taxonomy. Further work is needed to produce a completed update, which can be formalised leading to the production of an ontology of collectives.

References

- [1] E. Bottazzi, C. Catenacci, A. Gangemi, and J. Lehmann. From collective intentionality to intentional collectives: an ontological perspective. *Cognitive Systems Research*, 7(2):192–208, 2006.
- [2] M. Donnelly, T. Bittner, and C. Rosse. A formal theory for spatial representation and reasoning in biomedical ontologies. *Artificial Intelligence in Medicine*, 36(1):1–27, 2006.
- [3] G. Guizzardi. Ontological foundations for conceptual part-whole relations: The case of collectives and their parts. *Advanced Information Systems Engineering*, pages 138–153, 2011.
- [4] S. Schulz, K. A. Kumar, and T. Bittner. Biomedical ontologies: What part of is and isn't. *Journal of Biomedical Informatics*, 39(33):350–361, 2006.
- [5] A. Rector, J. Roger, and T. Bittner. Granularity, scale and collectivity: When size does and doesn't matter. *Journal of Biomedical Informatics*, 39(3):333–349, 2006.
- [6] H. Arrow and J. E. McGrath. Member dynamics in groups at work: A theoretical framework. *Research in organizational behavior*, 17:373–373, 1995.
- [7] A. V. de Ven. On the nature, formation and maintenance of relations among organisations. *Academy of Management Review*, 1(4):24–36, 1976.
- [8] G. Boella and L. van der Torre. A foundational ontology of organisations and roles. *Declarative Agent Languages and Technologies IV*, pages 78–88, 2006.
- [9] Z. Wood and A. Galton. A taxonomy of collective phenomena. *Applied Ontology*, 4(3-4):267–292, 2009.
- [10] Z. Wood. *Detecting and Identifying Collective Phenomena within Movement Data*. PhD thesis, University of Exeter, 2011.
- [11] Z. Wood. Profiling spatial collectives. In M. Bramer and M. Petridis, editors, *Incorporating Applications and Innovations in Intelligent Systems XXI Proceedings of AI-2013, The Thirty-third SGAI International Conference on Innovative Techniques and Applications of Artificial Intelligence*, pages 95–108. Springer, 2013.
- [12] M. E. Winston, R. Chaffin, and D. Herrmann. A taxonomy of part-whole relations. *Cognitive Science*, 11:417–444, 1987.
- [13] C. Masolo, L. Vieu, E. Bottazzi, C. Catenacci, R. Ferrario, A. Gangemi, and N. Guarino. Social roles and their descriptions. In *KR*, pages 267–277, 2004.
- [14] F. Steimann. Data and knowledge engineering. *On the Representation of Roles in Object-Oriented and Conceptual Modelling*, 35:83–106, 2000.
- [15] G. Boella and L. van der Torre. An agent-orientated ontology of social reality. In *Proceedings of FOIS*, 2004.
- [16] B. Smith. On classifying material entities in basic formal ontology. In *Interdisciplinary Ontology. Proceedings of the Third Interdisciplinary Ontology Meeting*, pages 1–13, 2012.
- [17] O. Pacheco and J. Carmo. A role based model for the normative specification of organized collective agency and agents interaction. *Journal of Autonomous Agents and Multi-Agent Systems*, 6(2), 145–184.
- [18] K. D. Benne and P. Sheats. Functional roles of group members. *Journal of social issues*, 4(2), 1948.
- [19] T. Bittner, M. Donnelly, and B. Smith. A spatio-temporal ontology for geographic information integration. *International Journal of Geographical Information Science*, 23(6):765–79, 2009.
- [20] A. Artale, N. Guarino, and C. M. Keet. Formalising temporal constraints on part-whole relations. In *KR*, pages 673–683, 2008.
- [21] N. Guarino and C. Welty. A formal ontology of properties. In R. Dieng and O. Corby, editors, *Knowledge Engineering and Knowledge Management Methods, Models, and Tools: 12th International Conference, EKAW 2000*, pages 97–112, Juan-les-Pins, France, 2000. Springer.
- [22] A. Davis and L. Barrett. Relations among roles. In *The Ontologies and Lexical Knowledge Bases Workshop (OntoLex02)*, pages 9–16, 2002.