

An Ontology of Modern Military Organizations and their Structure

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Abstract

Abstract: While the technology of warfare is constantly changing, particularly in the areas of weapons, equipment, mobility, and communications, the fundamental structure of military organizations has remained stable since Roman times. In this paper we present an ontology of the basic categories and relationships needed to represent modern military organizations (i.e. government-sponsored non-paramilitary organizations). In particular, we focus on the subordination relationships and command and control flows that bind military organizations together.

Introduction

Our ontology of military units and their structure attempts to distill out the features of military organizations that have remained stable over the history of organized state-sponsored warfare. The discussion that follows will be conducted with respect to that context. Specifically, we restrict the discussion to those sub-organizations of modern nation-states that are constituted with the goal of furthering the political goals (either attack, defense, police action, or employment for non-belligerent tasks) of those states through the use of armed force.

The existence of trans-national military organizations, such as those formed for United Nations peacekeeping activities, alliances such as NATO, state-sponsored terrorist groups, and state-sanctioned paramilitary organizations present difficulties for this model. Such organizations have similar hierarchical structures and thus could be combined with the current model to form a more general model. In the interests of simplicity, we do not address those questions in this paper.

General terminology and concepts were provided by [Dupuy 1986], [Arkin 1990] and [Army 1997]. In the first section of the paper, we discuss general features of the model. In the second section we introduce the main classes of the model¹ and then introduce the important concepts of

¹ In our own work we follow the more philosophically traditional terminology of Guarino and Welty [Guarino

echelon and subordination. In these sections, we discuss the intended meanings of the terms informally. Appendix A expands on this discussion by listing key axioms for the terms introduced.

A comment about terminology is in order. For the purposes of this discussion, whenever possible, we will reference the contents and incorporate the naming conventions of the standard upper ontology (SUO) being developed by the IEEE working group.

General Features of the Model

Some broad features of our model emerge immediately – modern military organizations have a hierarchical arrangement according to a relation that is loosely referred to as *subordination*. We will see later that subordination may be factored into finer-grained relations, giving it a partial-order rather than a tree-like structure.

We also divide the category of military organizations into those directly participating in subordination relations, such as units, and non-unit organizations that either exist independently of units or that make up the internal structure of units at each level of organization.

Important Classes

The core of the ontology consists of a set of property denoting terms covering what in [Guar 2000] are called the *backbone taxonomy* and a set of relation denoting terms that cover the relationships of subordination that provide military organizations with unity conditions². We assume the definitions of basic ontological relations such as

2000]. Unary relations are called “properties” while higher arity relational are simply called “relations”.

² [Smith 1999] suggests that organizations are a specific kind of entity he calls an agglomeration. Agglomerations have mereological unity conditions that delineate them from other agglomerations. We do not tie subordination to mereological notions, but such an extension would represent an important future direction for improving the model.

subsumption and argument typing for relations given in the emerging SUO standard.

We begin by introducing `ModernMilitaryOrganization` and `ModernMilitaryUnit` as they form the core of the ontology. For the remainder of this discussion these are abbreviated `MMO` and `MMU` respectively.

ModernMilitaryOrganization: The fundamental property in the ontology. Instances of `MMO` are the organizations referred to in the introduction which carry out military activities either as a whole (the US Department of Defense) or as (subordinate) components of such an organization (the 82nd Airborne Division). As implied by the name, `MMO` is subsumed by `Organization` in the SUO.

`NationalMilitaryOrganization` is an important subclass of `MMO`. Instances of this class are the national military organizations spoken of in the introduction, for example the US Armed Forces or the German Wehrmacht in World War II. They are maximal in that they are subordinate to no military organization (`MMO`). They are directly under the control of a government.

Most large modern militaries are traditionally broken into several branches of service. At first, these were land and sea forces. Later, with the advent of aircraft - air forces. However, there is no simple one-to-one correspondence between types of weaponry or areas of responsibility and branches of service. For example, the Soviet Union had (and now Russia has) strategic rockets under a separate branch of service while the US has such weapons under the control of the Air Force. For this reason, our ontology prescribes no fixed set of branches of service. We provide however the class `NationalMilitaryOrganization-BranchOfService`, instances of which are branches of service. It is also subsumed by `MMO`.

ModernMilitaryUnit: Next to `MMO` the most important class in the ontology is `ModernMilitaryUnit` (`MMU`). `MMU` is subsumed by `MMO`. Instances of `MMU` are functionally independent `MMOs` in that they can be (re)attached or (re)subordinated. Another way to put this is that `MMUs` are independent of other `MMOs` in the formal ontological sense (relative to subordination) [Simons 1987]. Contrast this with a military staff organization, which not an `MMU` itself but is dependent upon the existence of a "host" `MMU`.

Before we move on, we should say a few words about the nature of the properties discussed above. Three of them (`MMO`, `MMU`, and `NMO`) are what are called rigid properties³, meaning that once an entity instantiates such a property, it does not fail to instantiate it in any possible world where it exists. The last property (`NMO-BranchOfService`) would be a non-rigid property. As we

³ See [Guarino 2000] for formal definitions of rigidity for properties.

discussed above, branches of service are flexible - they can be shuffled around. Such a shuffle occurred after WWII in 1947 - the US Air Force was formed from the US Army Air Corps. One could still say there was continuity (i.e., the same organization) but where there was one branch of service (Army) prior to 1947, after that date there were (and still are) two.

Echelon Structure

One important notion found in all modern militaries is the notion of echelon. Within an armed service, we talk of fleets, divisions, squadrons, platoons, centuries, etc. These groupings are called echelons. Echelons are a set of standard "sizes" into which units can fall. Thus they are like discrete measurements (tall-grande-vente⁴). Some militaries take the notion more seriously (the Union Army in the Civil War) and some less seriously (the Confederate Army in the Civil War).

First off, echelons are idiosyncratic - particular to `NMOs`. While many countries (including the US) use a system inspired by French military history, there are variations. A US infantry division cannot be directly compared in strength to a Russian infantry division. They're simply different beasts, designed to fit different countries' doctrines of warfare.

For these reasons, we define the class `MilitaryEchelon` as a subclass of `Attribute` and the (functional) relation `echelon` to map instances of `MMU` to instances of `MilitaryEchelon`. Echelons within a `NMO` form a partial order. For the US, division is "higher" than brigade, which is "higher" than battalion. We represent this ordering with the relation `subEchelon`. The `subEchelon` relation is transitive and asymmetric. One feature of echelon structures is that they provide important constraints on the subordination relation. If *A* and *B* are instances of `MMU`, and *A* is subordinate to *B*, then *A* must be of a lower echelon than *B* in the ordering.

Flavors of Subordination

A defining characteristic of military organizations is that they are strictly hierarchical - organized by subordination relations. Commands, administrative and logistic support flow down these hierarchies, and information flows up. In real life (especially in wartime) the situation is often more fluid than this, especially for support relationships.

The most general subordination relation we define between `MMOs` is `subordinateTo`⁵. `MMO A` is subordinate to `MMO B`

⁴ Why coffee shops don't simply use small, medium, and large is beyond us.

⁵ We view `subordinateTo` as simply the restriction of a

just in case *A* is dependent on *B* for any of the aforementioned reasons.

Looking inside the subordination relation, finer distinctions arise with respect to units (instances of MMU) [Army 1997]. There are *ways* that an organization (MMO) may be subordinate to a unit (MMU): *assignment*, *attachment*, and *operational control*.

As we mentioned above, there are really three ways for an organization to be subordinate to a unit, depending on how tightly "bound" the subordinate organization is. This binding is expressed in term of three dimensions. For MMO *A* subordinate to MMU *B*, *A* may be "bound" to *B* in three ways:

1. *A* receives administrative support (paychecks) from *B*
2. *A* receives logistic support (food, ammo) from *B*
3. *A* receives operational orders from *B*

Let's take the three types of subordination in increasing order of "strength" along the three dimensions just mentioned.

The relation *opconMOrg* relates a MMO *A* and MMU *B* just in case *A* gets operational orders from *B*. Operational orders do not include personnel actions and other administrative details - they are orders for *A* to do what *A* is constituted to do (for a combat unit *A* - this means fight). In this case *B* simply tells *A* what to do. It is still up to *A* to obtain (non-operational) support - *B* does not do that for them. This relation crops up mostly in wartime or during peacetime training operations.

Moving up the ladder in strength is *attachedMOrg*, denoting the relation of attachment. When *A* is attached to *B*, *A* receives operational orders from *B* as well as logistic support. Thus, *attachedMOrg* implies *opconMOrg* for *A* and *B*. This relation obtains typically when *A* is "on loan" to *B* for some extended period of time longer than a single operation.

The strongest relation of subordination is *assignment*, denoted by the term *assignedMOrg*. This is the canonical relation of assignment indicated in static orders of battle, for example the 175th Infantry Regiment being assigned to the 29th Infantry Division at the time of the Normandy invasion in 1944. In this case, if MMO *A* is assigned to MMU *B*, *A* not only receives operations orders and logistic support from *B*, but also administrative support. Thus, *assignment* implies the two weaker forms of subordination - *attachment* and *operational control*. Assignments are typically very long-lived, and are rarely changed over the life of a unit.

general sub-organization relation to MMOs.

A note about the formal character of these relations is required here. All three relations are functional, meaning there can be only one target of assignment, attachment, or operational control. Since the three relations are connected by implication (assignment → attachment → operational control), this implies that some non-monotonic mechanism is required to capture their intended interpretations. To see this, consider *A* being assigned to *B*. During this time, *A* is temporarily attached to *C*. But since assignment implies attachment, *A* is also attached to *B*. Since attachment is functional, this cannot be - something has to give. In this case *A* being assigned to *B* only non-monotonically implies *A* being attached to *B*. This weaker attachment must be overruled by the more immediate attachment of *A* to *C*, as well as the implied operational control of *A* by *C*.

Conclusion and Future Work

The terms described here are part of a far more comprehensive ontology developed by the authors while they were employees at the Department of Defense. This ontology was used as the basis for several successful database applications at DoD and formed the basis for much of the ontology of military organizations used by Teknowledge and Cycorp for their work in the DARPA HPKB initiative.

We have provided only a brief overview of an ontology of military organizations and their structure. In particular we have omitted discussion of the internal structure of military organizations, to which a great deal of the ontology is devoted.

Much more work will be required to bring this ontology into alignment with the emerging SUO standard. Also we feel the need for non-monotonic treatment of negation as suggested in our discussion of subordination relations is an important open issue for the SUO effort.

Acknowledgements

The authors wish to thank the many DoD analysts and military personnel who helped us develop and clarify the work presented here. We would also like to thank Fritz Lehmann of Cycorp for his comments.

References

[Arkin 1990] Arkin, W.M., Handler, J.M., Morrissey, J.A., Walsh, J.M., Encyclopedia of the U.S. Military, Harper & Row, NY, 1990.

[Army 1997] Army field manual, FM 101-5. Headquarters, Department of the Army, Washington, DC, 31 May 1997.

[Dupuy 1986] Dupuy, T.N., Johnson, C., Hayes, G.P., Dictionary of Military Terms, The H.W. Wilson Company, NY, 1986.

[Guarino 2000] Guarino, N., Welty, C. A Formal Ontology of Properties, in *Proceedings of the 12th International Conference on Knowledge Engineering and Knowledge Management*, Lecture Notes on Computer Science, Springer Verlag, 2000.

[Simons 1987] Simons, P., Parts: A Study in Ontology, Oxford, 1987.

[Smith 1999] Smith, B., Agglomerations, in Freksa, C. ed., *Spatial Information Theory. International Conference COSIT '99* Lecture Notes in Computer Science, Springer Verlag, 1999.

Appendix A: Axioms

In this appendix we give a sampling of the salient axioms for the concepts introduced in this paper, using as far as possible the terms defined so far by the SUO.

```
(subclass-of ModernMilitaryOrganization Organization)
(subclass-of ModernMilitaryUnit
  ModernMilitaryOrganization)
(subclass-of NationalMilitaryOrganization
  ModernMilitaryOrganization)
(subclass-of ModernMilitaryOrganization-BranchOfService
  ModernMilitaryOrganization)
(subclass-of MilitaryEchelon Attribute)

(instance-of echelon BinaryRelation)
(nth-domain echelon 1 ModernMilitaryUnit)
(nth-domain echelon 2 MilitaryEchelon)

(instance-of subEchelon BinaryRelation)
(nth-domain subEchelon 1 MilitaryEchelon)
(nth-domain subEchelon 2 MilitaryEchelon)

(instance-of subordinateTo BinaryRelation)
(nth-domain subordinateTo 1 ModernMilitaryOrganization)
(nth-domain subordinateTo 2 ModernMilitaryOrganization)

(instance-of assignedMORg BinaryRelation)
(nth-domain assignedMORg 1 ModernMilitaryOrganization)
(nth-domain assignedMORg 2 ModernMilitaryUnit)

(instance-of attachedMORg BinaryRelation)
(nth-domain attachedMORg 1 ModernMilitaryOrganization)
(nth-domain attachedMORg 2 ModernMilitaryUnit)

(instance-of opconMORg BinaryRelation)
(nth-domain opconMORg 1 ModernMilitaryOrganization)
(nth-domain opconMORg 2 ModernMilitaryUnit)

;; Axioms

(forall (?x)
  (=> (NationalMilitaryOrganization ?x)
    (not (ModernMilitaryUnit ?x))))

(forall (?x)
  (=> (NationalMilitaryOrganization-BranchOfService ?x)
    (not (ModernMilitaryUnit ?x))))

(disjoint NationalMilitaryOrganization-BranchOfService
  NationalMilitaryOrganization)

(forall (?x ?y)
  (=> (subordinateTo ?x ?y)
    (or (assignedMORg ?x ?y)
        (attachedMORg ?x ?y))))
```

```
(opconMORg ?x ?y))))

(forall (?x ?y)
  (=> (assignedMORg ?x ?y)
    (subordinateTo ?x ?y)))

(forall (?x ?y)
  (=> (attachedMORg ?x ?y)
    (subordinateTo ?x ?y)))

(forall (?x ?y)
  (=> (opconMORg ?x ?y)
    (subordinateTo ?x ?y)))

;; non-monotonic
(forall (?x ?y)
  (=> (assignedMORg ?x ?y)
    (and (attachedMORg ?x ?y)
         (opconMORg ?x ?y))))

;; non-monotonic
(forall (?x ?y)
  (=> (attachedMORg ?x ?y)
    (opconMORg ?x ?y)))

(forall ((?x NationalMilitaryOrganization)
  (not (exists ((?y ModernMilitaryOrganization)
    (subordinateTo ?x ?y)))))

(forall ((?x NationalMilitaryOrganization)
  (exists ((?y Country)
    (subOrganization ?x (GovernmentFn ?y)))))

(forall ((?x ModernMilitaryOrganization-Staff)
  (exists ((?y ModernMilitaryUnit)
    (subordinateTo ?x ?y))))

(forall ((?x ModernMilitaryUnit)
  (?y ModernMilitaryUnit))
  (=> (and (echelon ?x ?x-ech)
    (echelon ?y ?y-ech)
    (subordinateTo ?x ?y))
    (subEchelon ?x-ech ?y-ech)))
```