Warfighters, Ontology, and Stovepiped Data, Information, and Information Technology

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November 14, 2012

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The Operational Problem. Warfighters and others in DoD need to share warfighting and business data and information across and beyond DoD easily. Today's impediments to such sharing need to be remedied because they hinder DoD realizing the efficiency and effectiveness required to remain affordable and effective. Data and information that cannot be easily shared machine-to-machine between domains, specialties, organizations, and information technology (IT) systems is characterized as being stovepiped (i.e., a system that does not interoperate with other systems).

This Document's Contribution. This document explains concepts and methods essential to:

(1) Creating data, information, and IT systems that are not stovepiped, and

(2) Integrating data, information, and IT systems that are stovepiped.

Reality is not Segmented. The first and most important concept is that reality is an integrated whole, not a collection of mutually exclusive domains. Each specialty (e.g., medicine, logistics, intelligence, etc.) is a different perspective of our common reality. In medicine, a person can be a caregiver and patient. In logistics, a person can be a passenger, a customer, or a worker. In intelligence, a person can be an intelligence specialist or a target. Indeed, a person can fill all these roles simultaneously.

Three Orders of Reality. Situational awareness (i.e., understanding reality) is generally understood to be essential for success. It is also generally understood that people often misunderstand reality. The theory of ontology, the modeling of reality, addresses the disparities between reality and what people think is reality by defining three orders of reality.

(1) 1st Order. *Reality as it is*. In the action in the upper image to the right, reality is what is, not what we think is happening as we peer through the fog of war.

(2) 2nd Order. *What we believe is happening* as we peer through the fog of war. Examples: what a participant in the action shown in the upper image or a member of an operations center in the lower image believes is occurring in the engagement.

(3) 3rd Order. *Reality as we record it*. In the lower image, the computer displays are 3rd order reality.

We create 2nd and 3rd order realities with symbols (e.g., words and map icons). Gaps between orders of reality introduce risk. These gaps are not the only form of risk, but reducing these gaps contributes to reducing risk.

Role of Words and Other Symbols. Closing these orders-of-reality gaps starts with aligning the words and other symbols we use to create our 2nd and 3rd order realities with 1st order realities. People have difficulty comprehending something for which they do not have a word or other symbol. It is nearly impossible to communicate or record an aspect of reality for which we lack a word or other symbol.

Creation and Use of Words and other Symbols. People usually create words and symbols in response to specific problems in specific domains. The natural result of this reality is sets of words or vocabulary focused on specific domains (i.e., stovepiped data, information, and IT systems). However, organizational effectiveness and efficiency require that data and information in one domain or IT system be shared and used by members of other domains and the IT systems these individuals use.

The challenge, therefore, is how to facilitate creating terminology and other symbols based on a particular type of problem or specialty (e.g., improvised explosive devices [IED]) that are easy to integrate and use with terminology and others symbols for other types of problems and specialties.

The solutions include:

(1) Using the same words and other symbols across specialties (e.g., for command and control, operations, logistics, and intelligence);

(2) Grouping words and other symbols that are common among different specialties according to common categories (e.g., the category or class "sensor" can be used by logistics for devices that sense engine problems on trucks and for the instruments used by intelligence agencies to generate images); and

(3) Developing a vocabulary for a specialty or domain that represents its basic elements (e.g., a model of an infantry company intended to facilitate personnel management that extends beyond the concept of a company to include individual soldiers, not just platoons, squads, and fire teams).

Avoid Conflation. Conflation is when two or more independent concepts are combined into a single concept with a single term and definition. Example:

Attack Geography – a description of the geography surrounding the…incident, such as road segment, buildings, foliage, etc. Understanding the geography indicates enemy use of landscape to channel tactical response, slow friendly movement, and prevent pursuit of enemy forces.

In this example, the definition for attack geography conflates (i.e., aggregates) two related but separate categories. The first category is the aspect of reality that is of interest (i.e., the area where an attack occurred). The second category is a description (e.g., verbal statement, written report, or map overlay) of the area. Going back to the orders of reality, an area where an attack occurs is part of first-order reality. A description of that area is an element of second- or third-

order reality depending upon whether the description is in someone's memory or is in a document. Usually, there are multiple descriptions produced by various observers of any area where an attack occurred. None of the descriptions is completely accurate and no report contains all the details. In practice, members of an operations center distinguish between reports they receive about an incident and the incident itself. Experienced members of operations centers know that they need to collect and study multiple reports to understand an incident because each report is likely to (1) contain some inaccurate information and (2) have only some of the needed details.

The concept of attack geography as defined above should have been divided into two concepts (i.e., two pairs of terms and definitions) – attack geography and description of attack geography. Because the definition above is conflated, it obscures the crucial distinction between what is described and the description. This conflated definition also invites mistaken beliefs such as there can be one authoritative and complete and accurate description (e.g., report) of the area in which an attack occurred when, in fact, there will almost always be (1) multiple reports and (2) some information that is believed to be true but is not true.

Conflation by its nature introduces inaccuracies.

Base Definition on Essential Properties. Avoiding conflation is aided by basing a definition on the essential property of what is being defined. Returning to the definition above, the essence of attack geography is that it is an area or geography where an attack is planned, is occurring, or has occurred.

Non-Essential or Accidental Properties. For attack geography, accidental properties include the types of attacks (e.g., ambush, frontal assault, and attack by fire). Basing a definition on an accidental property causes conflation and produces an inaccurate definition. Returning to the definition of attack geography, if we define attack geography as an area where an IED incident occurred, then we have a definition which states that the concept of attack geography cannot be applied to ambushes, assaults, and attacks by fires.

Form Definitions Properly. The need to focus on essential properties leads to the following two steps when creating a definition.

> Step 1: refer to a *parent* class (e.g., Infantry Battalion: A Military Organization or Military Engagement: A Military Event).
>
> Step 2: add *differentia* (i.e., those properties that distinguish the thing being defined from all other things in its parent class).

These steps force several necessary considerations.

> First, what is the parent class? This will prompt someone developing a vocabulary for a particular problem or specialty (e.g., artillery fires) to ask what is the parent class for that domain (e.g., fire support).

Second, this facilitates inquiries into related problems and specialties (e.g., naval fire support and close air support) with the aim of identifying words and other symbols defined for the related problem or specialty that can be reused in the new vocabulary. It also should prompt an inquiry into the classes used by related specialties.

Example Definitions from Joint Publications

Fires — the use of weapon systems to create specific lethal or nonlethal effects on a target. (JP 3-09) (Note that the definition refers to a parent class [the use of weapons systems] and lists a certain differentia [to create specific lethal or nonlethal efforts on a target]. This points to fires as part of a larger realm - the use of weapons systems for any purpose)

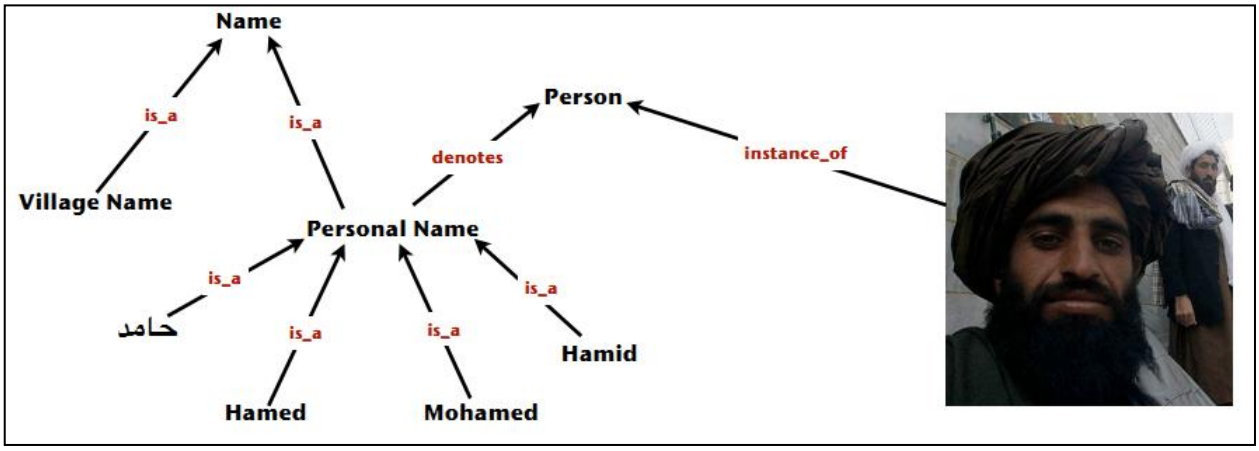
Final protective fire — an immediately available prearranged barrier of fire designed to impede enemy movement across defensive lines or areas. (Note that the definition starts with reference the class "fires" and then states the differentia – an immediately available prearranged barrier intended to impede enemy movement across defensive lines or areas)

Counterfire — fire intended to destroy or neutralize enemy weapons. Includes counter-battery and countermortar fire. (JP 3-09) (Note again that the definition refers to the parent class and distinguishing element [i.e., destroy or neutralize enemy weapons])

Suppressive fire — fires on or about a weapons system to degrade its performance below the level needed to fulfill its mission objectives during the conduct of the fire mission. (Note that again the definition starts with a reference to the parent class)

Reality versus Convention. The orders of reality imply a difference between reality and the symbols we develop to represent reality. The most important difference between reality and our symbols for representing reality is that we cannot change reality but we can represent a feature in reality with any symbol we want to use. However, DoD efficiency and effectiveness are promoted by establishing and following conventions or standards that map words and other symbols to features in reality. The English word "water" and the French word "l'eau" are equally good symbols for H_2O. Which is appropriate depends on convention or the language of those seeking to communicate.

Relationships. If one, as is suggested above, models reality with terms that represent the smallest relevant elements (thus avoiding conflation), these elements must be connected with relationships. In the image below, various smallest-possible elements are connected. The reality



of the person is represented by the photograph. This cannot be changed by someone performing ontology, the modeling of reality. Use of the terms and concept of *person* to represent the real individual, however, is a matter of convention (i.e., agreement or authoritative direction). Any number of terms and definitions might be used. What is required is uniform understanding and application of a term in modeling reality. The connection between a real person and his representation is the relationship "Instance_of". This and other relationships used in modeling reality need to be codified by convention (e.g., recorded in an authoritative data source).

Note that the essential property of the individual (i.e., that he is a person or homo sapien) is separated from his various names. To avoid conflating a specific name with the person, an intermediate concept or class of "Personal Name" has been used and connected to person by the relationship "denotes" and to specific names used by that individual with the relationship "is_a". Note also that the designer of this model sought and found the class to which "Personal Name" belongs – "Name". Understanding the broader class may facilitate representing information about this person.

Invest in Ontological Foundation. The model on the previous page is irrelevant if one is simply interested in knowing a name of the individual shown in a picture. Operational success in Iraq and Afghanistan, however, required a capability to associate one individual with multiple names because a single Afghan or a single Iraqi sometimes used multiple names. The mental model that each Afghan and Iraqi uses only one name is not aligned with reality and has facilitated adversaries slipping through our fingers by using different names at different times and places. A database that treats a person's name as his essential property is not only ontologically incorrect but also hinders or precludes recording multiple names for the same individual.

Purpose and Scope of Document Review. This document is intended to alert those seeking to rapidly develop sound situational awareness about the need to understand and apply the concepts and methods of ontology. This document also seeks to illuminate the need to understand and use these concepts and methods when attempting to implement information sharing and reuse across

an organization. Everyone uses ontology (i.e., models reality) as they puzzle through what is occurring around them and determine how to accomplish assigned tasks or missions. Those who understand the concepts and methods of ontology have an advantage over those who (1) create stovepipe data, information, and IT systems through inadvertent conflation, poor definitions, and domain models that are poorly aligned with reality and (2) do not support simple but critical capabilities such as relating a single person with multiple names.

Conclusion. Because there are many more ontological concepts and methods than those explained in this short document, those who would exploit ontology need to learn more about ontology or gain access to advisors schooled and experienced in ontology. It is important to understand that there is a difference between someone who uses software such as TopQuadrant that is intended to support ontology and someone educated in the concepts and methods of ontology. This is similar to the distinction between someone who can use Microsoft Word software and someone who can write a good book.

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