

Command Information Infrastructure and Sense-making

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Abstract

This paper is concerned with sense making and its implications for military command information infrastructure and interfaces.

The physical, information and cognitive domains described in the literature on Network Centric Warfare have been considered and it has been concluded that the information domain does not actually contain "information". It is suggested that it be more accurately described as a representational or symbolic domain.

A process of encoding a representation of physical reality from the physical domain through a subjective filter or "lens" and perceiving the representation through a further filter into the cognitive domain is described. The process can also be considered in the reverse direction, by forming a model of an individual's way of viewing the world, representing their cognitive construct of how they see a future situation in order to share this vision with others e.g. to communicate a Commander's intent.

This presents a problem for military Command Infrastructure teams and individuals in that if representation or transfer processes are not appropriate to another's way of thinking, then completely wrong conclusions can be made.

This has implications for the design of Information Systems in that we are inherently developing them in particular ways of perceiving the world (Physical or Cognitive). As a result we may make the wrong conclusion or not be able to make sense of a particular representation at all due to the representation appearing incoherent.

The paper discusses how the above process can be improved in order to prevent ambiguity and convey intent without confusion.

1. Introduction

It can be argued that we make incorrect assumptions both as system designers and system users that may be dangerous. One such assumption is that systems actually contain

'information' when they do not. The language that we have adopted to help us categorise such systems e.g. "information systems", "knowledge systems" and "situational awareness display", tend to reinforce this assumption.

This view of information systems distorts our perception of how situation understanding is developed i.e. how sense making occurs. In a net-centric environment we will be attempting to share information more widely through the medium of technology and develop similar cognitive constructs such as those denoted by 'shared situational awareness' and 'sharing of command intent'. Actually at the base level we are sharing representations. This sharing of representations may or may not result in the sharing of information, in fact it may result in the incorrect information being shared or a state of confusion being generated. Unless we can develop a better understanding how information and meaning is conveyed, net-centricity may significantly increase the magnitude of information sharing failures, resulting in more misunderstandings and inappropriate action. This has major implications for the success or otherwise for self-synchronisation.

To resolve this we need to: develop a better understanding of (a) the differences between representation and information and (b) the philosophical assumptions we use when designing systems. Also we need to educate system designers and users of the consequences for them of this understanding.

2. Information versus representation

In the literature on network centric warfare, [Alberts, 2001] an information transformation process is described, which crosses the boundaries between three domains i.e. the physical, information and cognitive. Events or states in the physical world are sensed and these are converted into representations in the information domain. However, at this point we do not have meaning or understanding, rather as Devlin states we only have data: -

"Data is what newspapers, reports, and "computer information systems" provide us with". [Devlin, 1999]

Perhaps though, we have something that is even more abstract than data. For example, at the most basic level, the newspaper is simply paper with a pattern of ink on it. Through skills and knowledge we have attained by previous experience, we can perceive that the patterns of ink actually represent symbols and that these symbols are formed into sequences as defined by a language. Unconsciously, people are using a tremendous amount of knowledge and previous learning experience to convert the patterns of ink into information that can be used in the cognitive domain.

The observant reader may have noticed that there appears to be a terminological difficulty here. We have a domain labelled "information" but the domain does not actually contain information. Rather it contains sets of symbols or representations. It is only when people interpret these sets of symbols, using their considerable knowledge, that they can be converted into information that can be acted upon. Perhaps therefore, it would be more correct to envisage that information, together with knowledge, only existing within the cognitive domain i.e. in the minds of people.

"To conceive of knowledge as a collection of information seems to rob the concept of all of its life... Knowledge resides in the user and not in the collection. It is how the user reacts to a collection of information that matters." [Churchman, 1971]

The two transformation processes described above are complex and not well understood. They act like filters or lenses that promote the transfer of particular views or perspectives, and demote others. These lenses are also not fixed. They vary between individuals, perhaps between cultures and they may also be dependent on how people are predisposed at particular points in time.

There is, however, another factor that affects the manner in which people make sense of the representations we have in our "information systems", and this is the philosophical position that is taken. When we say 'position' this is not meant to imply that people have consciously chosen to take one particular philosophical view or another, but rather that particular ways of thinking and viewing the world are consistent with one or more of the philosophical positions. In order to understand this point, we need to discuss briefly a number of these philosophical positions.

3. Objectivism, Constructivism and Realism

Let us start with objectivism. Objectivists believe that there is a rational world that is independent of the thinker. They also believe that there is some inherent structure to the world and that to make sense of the world requires one to create cognitive constructs that mirror the external reality and its structure.

The major philosophical assumptions of objectivism including those of Jonassen [Jonassen, 1992] and Lakoff [Lakoff, 1987] is that: -

- There is a real world consisting of entities structured according to their properties and relations. Categorization of these entities is based on their properties.
- The real world is fully and correctly structured so that it can be modelled.
- Symbols are representations of reality and can only be meaningful to the degree that they correspond to reality.
- The human mind processes abstract symbols in a computer-like fashion so that they mirror nature.
- Human thought is symbol-manipulation and it is independent of the human organism.
- The meaning of the world exists objectively, independent of the human mind and it is external to the knower.

In contrast, constructivists believe that there is no such thing as an objective reality, that what we perceive of as reality is actually a human construction.

The basic and most fundamental assumption of constructivism is that knowledge does not exist independent of the learner. Knowledge is constructed. The major philosophical assumptions of constructivism including those of Jonassen [Jonassen, 1992] is that: -

- There is a real world that sets boundaries to what we can experience. However, reality is local and there are multiple realities.
- The structure of the world is created in the mind through interaction with the world and is based on interpretation. Symbols are products of culture and they are used to construct reality.
- The mind creates symbols by perceiving and interpreting the world.
- Human thought is imaginative and develops out of perception, sensory experiences, and social interaction.
- Meaning is a result of an interpretive process and it depends on the knowers' experiences and understanding.

There are two key variants of constructivism, personal and social. According to personal constructivists, knowledge is constructed in the head of learners while they are re-organizing their experiences and cognitive structures. For the social constructivists, knowledge is constructed in communities of practice through social interaction. There are others who argue that the two views cannot be separated because they complement each other.

Another philosophic stance combines features of both objectivism and constructivism, that of a 'realist'. A realist accepts that there is a real world consisting of entities structured according to their properties and relations, however it cannot be accessed other than through a constructivist approach.

4. Implications for Command and Command Systems

4.1 *Command*

Dependent on whether one accepts an objectivist, constructivist or realist view, there are some major implications for the way military command systems are constructed and operated, the way that data is managed in these systems and the way that sense making should occur and be supported.

One could argue that successful commanders, have been at least partly constructivist or realist in nature. In fact, some of the doctrinal command processes have within them the view that a number of different perspectives need to be considered when undertaking a situation assessment. However, with the rise of the technologists, the scientists and the technology they create has come an increasing belief in an objective reality. There has been an increasing focus on 'hard' outputs from sensors, and a belief that one can construct a model of reality inside the technology. This view was perhaps taken to the extreme in the Vietnam war, where there was a belief that if the quantitative values in the Rand developed model said that the war was being won, then this was what was happening in reality. As pointed out by [Baumard] there was a difference between what was believed from the model and actually knowing or understanding what was happening. However, these assumptions continue today, as evidenced in the concept and instantiation of Common Operating Pictures.

4.2 *Common Operating Picture*

As a consequence of the philosophical discussion, there appear to be some significant issues with the intent, nature and use of the COP. For many observers, the connotation of the word

common is that the picture contains a single view of reality i.e. it contains the formal, valid and definitive view. However, considering how it is actually constructed, it is perhaps more correct to describe it as an aggregation of a number of representations of reality that asserts to be an authoritative view and as such a basis for common action. There is also a difficulty with the representation of time and uncertainty as the COP mixes representations referring to reality at different times and with different uncertainties resulting from a lack of accurate observation. Despite these differences, the COP tends to use the same representations, which subsequently makes meaning difficult to infer. So what the COP actually 'means' is a very difficult question to answer and open to much debate.

Consequently the resulting COP 'model' may be a poor representation of what is occurring in the physical situation, particularly if the situation is very complex, and rapidly evolving. This is particularly true when what is being modelled are not directly observable things like the location of tanks, but rather more abstract socially constructed elements such as the perceptions of the intents of factions operating in the conflict region.

Information Technology that presents a model of reality inside the equipment as a definitive or authoritative view of reality is tending to adopt an objectivist philosophical stance.

However, as Brian Wilson, a pioneer of the Soft Systems Method [Wilson, 1990] reminds us, we need to be aware that such models do not correspond to reality at all; they correspond to a model of a model of reality. What Wilson is implying is that sensors (whether human or technological) have a particular view (model) of the world and the way that this view is portrayed (modelled) influences the way we construct our own internal model. Therefore, we need to always be aware that when we examine a model, we are not viewing a definitive view of the world but a constrained and parochial view of it. This view is more consistent with a constructivist or realist philosophical stance.

If one accepts a more constructivist or realist view, that there are multiple truths and realities, we should be encouraging multiple perspectives, at least at the stage of situation assessment. It is important to note that constructivism does not reject the idea that a real world exists. Rather, it argues that the world can never be known in one single way. However, the physical world sets certain boundaries within which multiple perspectives can be negotiated and constructed. For constructivists and realists, learning is sense making.

4.3 Implications for Sense making

Designers of information systems may be striving to deliver systems that attempt to provide "absolute truth" about reality. However this may not be appropriate to the needs of military organisations at the strategic levels of command: -

"What we are seeking in sciences are true theories -- true statements, true descriptions of certain structural properties of the world we live in. These theories or systems of statements may have their instrumental use; yet what we are seeking in science is not so much usefulness as truth; approximations to truth; explanatory power, and the power of solving problems: and thus, understanding". [Popper, 1982]

Commanders and participants of command teams are not trying to get to some objective truth. Instead they need to know what action to take and need to know the consequences of that action. They attempt to do this by matching their experience to the situation that they face. In attempting to make sense of reality they have to construct a cognitive structure. The

properties of this structure are based upon the participant's view of reality, as it is perceived. The values of the objects within the conceptual structure are determined by their goodness of fit with the past experience of the participant.

"The world we live in can be understood also as the world of our experience, the world as we see, hear, and feel it. This world does not consist of "objective facts" or "things-in-themselves" but of such invariants and constancies as we are able to compute on the basis of our individual experience". [Von Glasersfeld, 1983]

The implication is that Commanders and participants of command teams need to share experiences and need to have social interaction in order to become informed. The transference of symbols from one to another is not sufficient to transfer a mental construct from one person to another as the mental construct is changed as it is represented by the symbols.

4.4 Implications for Shared Awareness

People may believe that they are talking about the same thing when they are not.

A person constructs a representation of a subject by using elements contained within an explanation of it, provided that he is somewhat familiar with and has established associations to the elements and other words used in the explanation. However, if the person is not given the explicit meaning behind the explanation, he is likely to construct an incorrect representation, which may then be used during communication about the subject without the mental image having to be adjusted. The error could be corrected only if the person's mental image comes into explicit conflict with another representation that is conveyed during communication.

When people attempt to communicate understanding to others they have a tendency to simplify explanations of complex phenomena in a linear fashion. This simplification is a necessary part of human communication because we must bridge the differences among our individual mental models in order to develop a working basis for collaboration. Feltovich et al call this the "*reductive bias*". [Feltovich, et al, 1997]

4.5 Implications for multi-national operations

Different parts of a multinational command organisation may view a situation in different ways as they may have quite diverse experiences and different doctrinal approaches. If the organisation adopts an objectivist philosophical approach at the strategic level, it may be difficult to work out whether one view is better than another. Therefore, the interpretation is that by adopting and supporting a socially constructed view of reality at the strategic level, the organisation is likely to form a better-shared understanding of reality, including an understanding of the organisation itself and its participants. This could be achieved by providing tools that encourage social interaction between participants and sharing an understanding of the multiple viewpoints and experiences of its members.

5. Conclusions

We must recognise that our Information systems do not contain information, only representations that can be interpreted in different ways.

People and technology have their own models of physical reality. This colours the choice of representation used and also how things in the physical domain map to the representations.

We need to understand the 'power' and limitations of particular representations of symbols and how people with different viewpoints can represent them in an explicit way. We would then have a basis for understanding better what the stored representations or models actually mean and therefore also what may be missing.

Technology is being developed that tends to focus upon an objectivist philosophy. However, it is incorrect to build all our IT systems around an assumption that we can represent a single objective, definitive or authoritative view of reality inside our equipment.

Objectivism may be more relevant at tactical echelons of command where decision-makers have to worry about directly observable activity.

A social constructivist or realist philosophical approach appears to be more appropriate to the context of military command organisations at the strategic level, particularly with regard to coalition and net-centric modes of working. The equipment should allow a pluralistic view of reality to exist and where a range of different sensors with different representations should be used – this would allow different perspectives to exist simultaneously.

We therefore, need an approach to system development and operation that provides a mixture of military Command and Control equipment that supports a graduated degree between objectivist, realist and constructivist views.

6. **What can we do about this?**

- Encourage our system designers to focus upon building systems based on a constructivist or realist view for users in the strategic level to allow social interaction and the sharing of experiences.
- Encourage the use of tools that allow a more explicit representation of events and experiences.
- Warn our commanders and command staffs about the dangers of the objectivist views in the technology and train them how to get around the problems that an objectivist viewpoint creates.
- Develop explicit training that focuses on the improvement of collective sense making skills.

The notion is to provide a medium for a socially constructed view of reality to form amongst the members of command teams – be they of one nation or many.

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