WORK DOMAIN ANALYSIS FOR ESTABLISHING COLLABORATIVE WORK REQUIREMENTS

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We explored the use of Work Domain Analysis (WDA) in the context of maritime tactical picture compilation. In particular, we were interested in extracting requirements for collaboration within a naval task group. This work presents a novel use of WDA, as this analysis method has not previously been used specifically to examine collaborative work processes. The WDA identified unique domain views for various team positions and collaborative boundary objects shared within the team. This use of WDA in a group context provides new requirements for the design of collaboration tools.

INTRODUCTION

A naval task group is a multi-purpose, combat-capable group of naval platforms, comprised of a number of combatants (e.g., destroyers, frigates, submarines) and a support ship, with appropriate air support. It is deployed as a group to achieve more substantial missions than a single platform could achieve on its own. Each platform has its individual tasking, yet the task group as a whole must coordinate their work in order to achieve the current mission. The composition of a task group depends on its mission, and is developed so the strengths of each individual platform are combined into an effective team.

Within the task group, all of the units in the task group contribute to the compilation of the Maritime Tactical Picture (MTP) through their efforts to assemble tactical information from their specific area. The MTP refers specifically to the formally maintained information in a tactical data system that is shared across the task group to enable the task group's command and control functions to be exercised based on a consistent, recognized understanding of the tactical situation. Each individual operator's interpretation of the MTP is affected by their own local knowledge of the tactical situation (either tacit or explicit) which may not always be formally recorded.

During task group operations, while each specific platform is responsible for assembling information from their own area, the control of the MTP for the task group is delegated to Force Track Coordinators (FTCs), officers on platforms designated to have specific warfare duties related to the air, surface, and sub-surface tactical pictures. These various warfare duties may be held on the same naval platform or ship, or may be distributed on different platforms.

This represents a truly collaborative and distributed environment where the FTC role for each warfare duty must collaborate with other roles to build the integrated MTP, possibly across different platforms. Of interest in this project, their collaboration is supported by data provided by the Track Supervisors on each platform, who each work with a team of sensor operators to make sense of the environment, and to pass recommendations for additions to the shared MTP to the responsible FTC. Individual action requirements must be negotiated within the context of the mission priorities of the overall task group.

Cognitive Work Analysis (CWA) has been shown to be useful in understanding naval domains in previous work (e.g., Torenvliet, Jamieson, & Chow, 2008; Burns, Bryant, & Chalmers, 2005; Naikar, Pearce, Drumm, & Sanderson, 2003). In these cases, however, the collaborative nature of the domain has been recognized but not addressed specifically. Burns et al. (2005) identified that multiple views were required to model naval domains appropriately but stopped short of identifying how those various views and entities might interact. While CWA as a method has not excluded collaborative domains from its scope of application, there have been relatively few explicit attempts to extend CWA models in such a way that collaborative requirements are clearly extracted. Naikar et al. (2003) has used CWA to develop training approaches for teams, and Hajdukiewicz, Vicente, Doyle, Milgram and Burns (2001) have used it to develop some early models of how surgeons and anaesthetists may interact in a work domain. While this work points to the potential of CWA for understanding collaborative work, it has not explicitly used CWA to define requirements that could improve collaboration. In this paper, we report on one phase, focused on establishing collaborative work requirements, of a larger project that used CWA to understand the collaboration work processes involved in MTP compilation.

METHOD

We conducted three phases of a CWA, a work domain analysis (WDA), a control task analysis, and a strategies analysis, looking at the cognitive work of the FTC(Surface) role, of which only the WDA is reported in this paper. We chose the surface role since the longer decision time of surface operations permits more collaboration. We studied existing documentation on CWA in a naval task group (Matthews, Keeble, & Sartori, 2007) and conducted a series of Subject Matter Expert interviews that focused on surface picture compilation and the collaboration required in developing a good tactical picture. We interviewed Subject Matter Experts who had performed the role of Track Supervisor in a task group, command level Subject Matter Experts who had served on ships with the FTC(Surface) warfare duty, and who were the ultimate consumers of the MTP, and Electronic Warfare Supervisors, who would typically send their information to the FTC(Surface). Interviews focused on the data requirements for a good MTP, how to assess picture quality, and how workers collaborate in this domain. We specifically probed for collaboration across shift changes, and incidents with collaboration breakdowns. We asked how Subject Matter Experts anticipate the needs of others on the team, how they proactively manage their own workload, and how they work with heavily loaded team members, novice team members, or highly experienced team members.

Following these interviews, work domain models were developed and then taken back to Subject Matter Experts for verification that the models described their work correctly.

RESULTS

In this section, we discuss the fundamentals of the work domain model for MTP from the perspective of the FTC(Surface) role. We then introduce our approach of layering collaborative requirements over this model, from which we have extracted design requirements for collaboration.

Work Domain Model

The work domain was modeled from three perspectives in three different but connected models in a manner similar to Burns et al. (2005). We modeled (1) the domain of a naval task group from the perspective of the FTC(Surface), (2) the MTP from the perspective of the FTC(Surface)'s role in MTP compilation, and (3) a generic surface contact from the perspective of the FTC(Surface). The decision to model these domains was made to respect the difference between real objects in the real world (models 1 and 3), and operators' perception of objects in the world as mediated by the sensors used to collect data about the environment, which is complicated by issues of picture quality and sensor management. This helped to ensure that the picture compilation issue was modeled appropriately but also to clearly differentiate between the pictured world and the actual world of the mission. This differentiation is important in this case since the closeness of the match between the pictured world and the actual world reflects the quality of the MTP. In Figure 1, we only show the high-level structure of the work domain model; each of these models was fleshed out in considerably more detail that is not relevant to the scope of this paper.

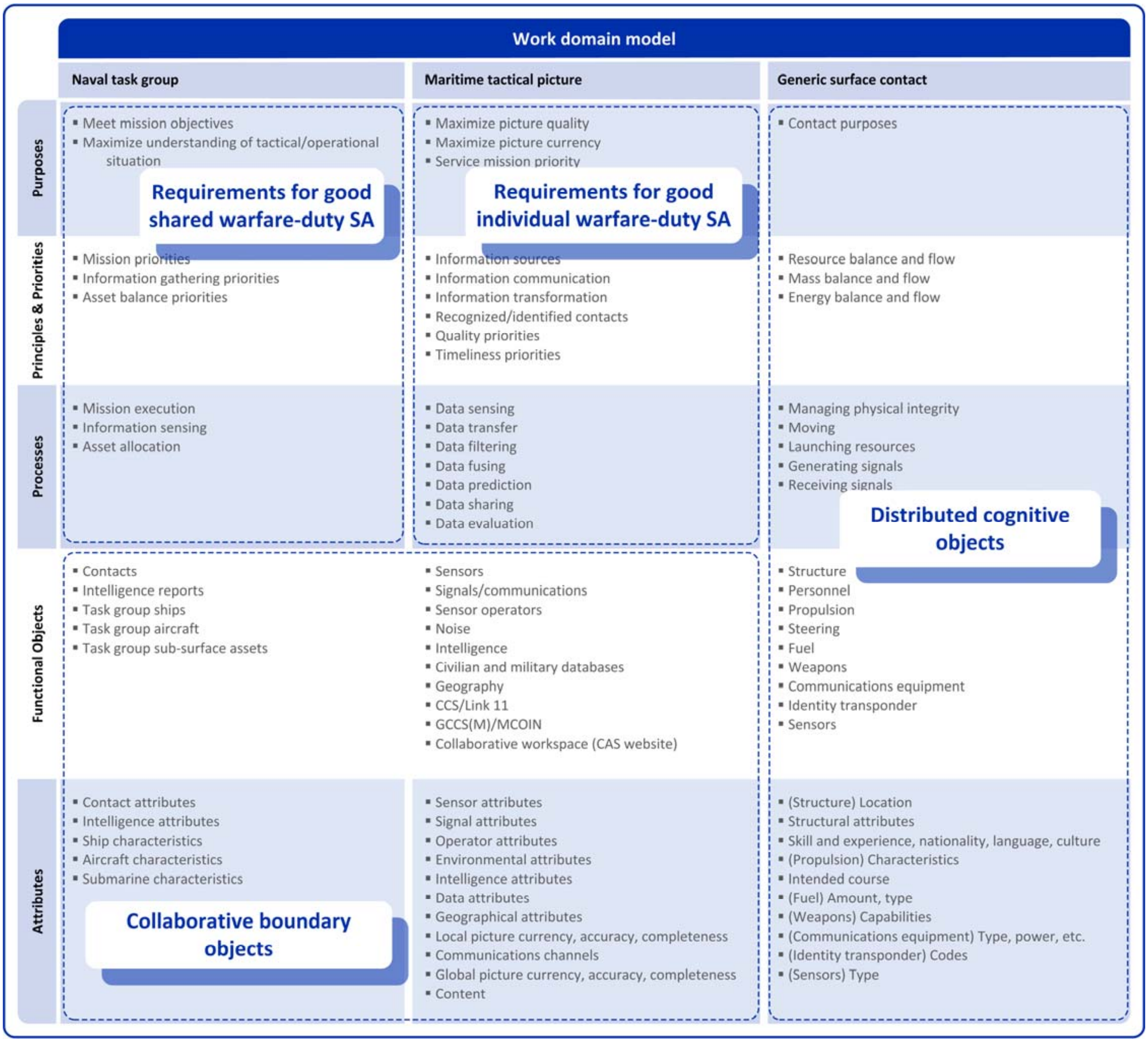

Figure 1. Work domain model of the collaborative domain of MTP.

Collaborative Work Requirements

We identified collaborative requirements in the work domain by developing a joint map of the three models. This map helped us to think about the ways in which the constraints of each model are used in collaborative work, and so helped us to identify the function of the various parts of the model in effective collaboration. This layer is shown with overlay boxes in Figure 1. In particular, we identified four different types of collaborative requirements from the work domain model.

It should be noted that the intent of a WDA is to provide an actor-independent perspective on the affordances of the work domain that could potentially be the subject of design. As a result, our model includes sensor operators (because they are affordances in the work domain from the perspective of our analysis) but does not include the Track Supervisors who compile the picture or the FTC role for each warfare duty (because they are the actors who are tasked with manipulating the affordances of the work domain). Since Track Supervisors and the FTC role for each warfare duty were not included in our models, requirements for maintaining effective collaboration between them cannot be uncovered through this approach. We expect that these requirements could readily be discovered by later phases of CWA such as Control Task Analysis and Strategies Analysis.

Requirements for good individual warfare-duty situation awareness. For the FTC(Surface) to have a good individual understanding of the current status of compilation and dissemination of the MTP, he or she needs to understand the quality of the current picture, how recently it has been updated, and to manage the processes of sensing, filtering and making predictions on how the current picture could change. These requirements tend to be limited specifically to the role of the FTC(Surface) and as a result are in the more abstract regions of his or her work domain, reflecting the FTC(Surface) individual objectives, priorities, and processes for handling picture compilation. Some of these requirements could be shared with other FTCs, though that was outside the scope of the current analysis.

Requirements for good shared warfare-duty situation awareness. For the FTC(Surface), task group command, and the individual task group members to collaborate effectively, certain knowledge must be shared across the team. In particular, these requirements include knowledge of the mission objectives, its priorities, what information is most important to collect, how task group assets will be used, and the general plan for the execution of the mission. Knowing this general context helps all team members to understand their role and to anticipate the actions of other team members.

Collaborative boundary objects. A boundary object is an object (either physical or conceptual) that bridges the gap between multiple parties. According to Star & Griesemer (1989), these objects "inhabit several intersecting social worlds…and satisfy the informational requirements of each of them" (p. 393). For example, a shopping list is a boundary object between a spouse who needs specific items for cooking and the spouse tasked with going to the store. In this domain, these objects are shared within the task group and may be used by one or more members of the task group. They may include various task group assets (e.g. ships, aircraft, sensors) and members of the task group itself. Members of the task group team will use these objects for various purposes. Successful collaborators share these objects effectively. For example, the task group commander may move a ship to a certain position while the FTC(Surface) requests certain information be gathered from that ship. Lack of shared understanding of these objects can lead to collaboration breakdowns (Subrahmanian et al., 2003).

Distributed Cognitive Objects. A distributed cognitive object is an object in the environment whose properties must be properly perceived to properly resolve the constraints in the work domain. In this domain, these objects are the contacts in the environment. These objects are typically assigned to different task group members now in charge of the information related to those objects.

How Collaboration Functions in the Work Domain

This analysis helps to clarify the way in which collaboration functions in the work domain. Human work in this domain conforms to a hierarchical structure in which the *requirements for good shared warfare-duty situation awareness* are relevant to understanding performance against the overall objectives of the task group, and in which these objectives are achieved through collaboration over the *boundary objects* that record and distribute the *requirements for good individual warfare-duty situation awareness.* The hierarchical work organization functions as a powerful collaborative data filtering and fusing function, that simplifies and structures information about the detail-level complexities of the *distributed cognitive objects* in the world in a way that is relevant to achieving the task group's shared objectives.

Design Requirements

This layering of the work domain has practical guidance for the design of collaboration tools. In particular, requirements for individual SA are design requirements that most likely should be limited to the individual displays for the FTC(Surface) role. This could include individual picture quality metrics, quality and timeliness priorities, and individual processes for picture improvement and prediction.

Shared SA requirements need to be available to all task group members through information displays and less formal methods of communication. All team members should be able to access and review mission purpose, progress, and priorities. This information, while possibly less concrete, is critical to allowing team members to negotiate their individual priorities correctly.

Collaborative boundary objects also need to be known explicitly. The capabilities, tasking, availability, and characteristics of task group members need to be known at minimum and in greatest detail by the asset themselves, the FTC, and central command of the task group. As coordination points across the group, all members of the task group may need some knowledge of these objects, but at a minimal level of detail or possibly not immediately accessible.

Distributed cognitive objects represent an opportunity for the distribution of work to various task group members. This information would typically be available in greatest detail and be most accessible according to assigned platform responsibilities for tracking particular contacts. At a more abstract level, the owner of that tasking is responsible for sharing this information to the task group through the FTCs.

CONCLUSIONS

WDA has for many years been shown to be a useful method for understanding complex work environments. While not excluding collaborative or team environments, the analysis has not explicitly offered many insights into how to design to support collaborative work. We showed in this project that a collaborative layer can be added to the WDA and information requirements from the WDA can then be examined explicitly for the role of these requirements in a collaborative context. This early work begins to extend CWA in an explicit manner to collaborative environments and allows CWA to become a workable tool to use when analyzing cognitive work in environments with a significant collaborative component.

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