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Weather Systems: A New Metaphor for Intelligence Analysis

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With the recent catastrophic outcomes in U.S. intelligence capabilities we suggest that current design metaphors are inadequate to address the changing reality of U.S. intelligence needs. In-depth interviews and concept mapping efforts with intelligence analysts suggest that the intelligence domain be characterized as a *distributed cognitive work system*. Current mechanical or information processing metaphors that encourage techno-centric system design solutions neglect the emergent, pluralistic and distributed nature of information that supports situational awareness and decision making in the intelligence domain. Instead, we suggest that weather systems are a more appropriate metaphor for understanding the cognitive activity of intelligence analysts and to guide the design of cognitive aides, information sharing and knowledge management systems, and data processing tools used to support intelligence work.

INTRODUCTION

The earmark of the intelligence analyst is an ability to arduously search through enormous volumes of data and band together scattered and seemingly unrelated events into a calculated estimation of a complex, dynamic situation. Requiring expert reasoning and judgment, the enigmatic environment of intelligence analysis is distinguished by the uncertain and deceptive nature of the information and is driven by the pressure to provide timely, accurate, and actionable information known as *intelligence*. In the role of problem solver, the goal of the analyst is to provide decision makers with information that may guide action.

Recent outcomes dependent on U.S. intelligence capabilities including the egregious September 11th, 2001 attacks , the “dead wrong” evaluation of Iraq’s weapons of mass destruction ("Report: Iraq intelligence 'dead wrong'", 2005, March 31) and the failure of the Federal Bureau of Investigation’s (FBI) $170 million dollar “Virtual Case File” (Frieden, 2005, February 3) create an imperative to reevaluate our understanding of both the factors that influence situational awareness and decision making in the intelligence community and the technical systems that support these processes.

Some of the erroneous conclusions have been attributed to single points of failure: poor problem solving mechanisms, information sharing and knowledge management, and data processing (Commission on the Intelligence Capabilities of the United States Regarding Weapons of Mass Destruction, 2005, March 31). However, in this paper, we argue that this lack of success (e.g. ability to accurately assess, predict, and prevent negative outcomes) in part can be attributed to a poor fit between current conceptualizations of the U.S. intelligence community and the actual cognitive work practices of this domain. More specifically, current metaphors used by systems designers to capture and represent the domain and work activities of intelligence analysts do not adhere to the tenants of a distributed cognitive work system. To highlight this lack of congruence in the integration between technology, analyst, and domain we present results from an exploratory cognitive work analysis with counterintelligence analysts and other literature. In conclusion, we suggest weather systems as a new metaphor for conceptualizing the characteristics of the domain, the cognitive activity of analysts, and the role of technology in the U.S. intelligence community.

THE USE OF METAPHORS IN SOCIOTECHNICAL SYSTEMS DESIGN

Metaphors play a critical role in system design as they frame the designer’s understanding and interpretation of the subsequent interaction between users, technology and a domain. Comparable to a paradox or an epistemology (Morgan, 2006), a metaphor provides a powerful lens for the way people see and think about the context and complexities of the world, even for aspects not empirically known to the designer. A well explored example is the comparison of the classic bureaucratic organization to a machine, fitting humans to the requirements of the mechanical organization. On the other hand, organizations as an organism or brain (i.e. information processing) have also been used as comparative images, where each suggests a different comprehension of and in turn, design for such systems (Orlikowski, 1992; Orlikowski & Iacono, 2001). Because metaphors are often used in the absence of experiences to guide design, a metaphor that creates a faulty or inaccurate view can produce miscues, errors, unintended consequences, or even catastrophic failure (Schultze & Orlikowski, 2001).

CURRENT CONCEPTUALIZATIONS OF INTELLIGENCE ANALYSIS

The mission of the U.S. intelligence community stems from supporting activities related to foreign policy and national security interests. Critical for those in decision making positions, intelligence analysis provides a level of situational awareness that reduces uncertainty and informs future courses of action. Historically, the process of intelligence analysis is illustrated using the six stage intelligence cycle model –*requirements & needs*, *planning*, *collection*, *processing*, *analysis*, and *dissemination.* The intelligence cycle model illustrates the classic bureaucratic and stove pipe-like style of centralized planning and operational hierarchies commonly associated with the U.S. Government (Bodnar, 2003; Clark, 2004). Metaphorically, this system is comparable to that of the classic mechanistic or machine like organizational style, setting a clear and rational chain of command and emphasizing the division of labor and specialization. In a more recently proposed alternative, Clark (2004) suggested a network-centric collaborative process as a more accurate depiction of post-Cold War intelligence practices. This network-centric process is less linear and exhibits a target- or problem-centric focus that is often transnational in nature. The network-centric approach takes an information processing view of the intelligence domain that distributes information and decision making across a network of people and suggests people work with incomplete and inaccurate information.

CHARACTERIZATION OF INTELLIGENCE ANALYSTS' WORK PRACTICES AND THE INTELLIGENCE DOMAIN

Our understanding of intelligence analyst work has emerged through six hours of face-to-face knowledge elicitation sessions with two counterintelligence analysts using procedural concept mapping (Zaff, McNeese, & Snyder, 1993) and critical incident probes (Klein, Calderwood, & McGregor, 1989). The activities as well as work domain of the analysts were analyzed and categorized using Vicente's (1999) five stage CWA model (work domain, control tasks, strategies, social-organization and cooperation, and worker competencies) and Elm et al.'s (2005) three major tasks of intelligence analysis (down collection, conflict and corroboration, and hypothesis generation). The elicited knowledge was modeled and represented in color coded concept maps and categorized tables. These maps were subsequently reviewed by a senior intelligence analyst (S. Taylor, Personal Communications, October 29, 2005) and compared to other concept maps done with image analysts for completeness and correctness (McNeese et al, 2004). Table 1 summarizes the identified activities organized using Elm et al.'s (2005) three major tasks in relation to Vicente's (1999) CWA framework.

Descriptions captured in the knowledge elicitation sessions suggest that the cognitive work activities of intelligence analysts do not take place in a vacuum, but rather occur in a domain characterized as complex, dynamic, high-stakes, ill-defined and uncertain. Overall, taskwork moved in an iterative and often chaotic pattern driven by the context and goals of the situation, the constraints of the domain, and the expertise of the analyst. Results also confirm that the cognitive demands were similar to the data availability paradox (Woods, Patterson, & Roth, 2002), the requirements of inferential analysis (Josephson & Josephson, 1994; Schum, 1987), and the capabilities and limitations of human cognition (Heuer, 1999). These claims are also supported by a small but growing number of empirical studies (Connors et al., 2004; Elm et al., 2005; Hutchins, Pirolli, & Card, in press; Patterson, Roth, & Woods, 2002; Scholtz, Morse, & Hewett, 2005). The demands that arise within intelligence analyst work are representative of a *cognitive work system* (Vicente, 1999). More specifically, analyst work can be defined as a *distributed cognitive system* (Hutchins, 1995; Salomon, 1993).

Returning to current metaphors of the intelligence domain, the intelligence cycle, in actuality, is an over-simplification of work practices and has been described as compartmentalized, inflexible, and an incomplete and inaccurate representation of intelligence work (Bodnar, 2003; Clark, 2004). The mechanical metaphor approach is incapable of capturing the interrelationships between tasks and actors as is true with the latest intelligence requirements. Clark's (2004) network-centric model, while better capable of understanding the new challenges of transnational targets (e.g. Al Qaida), still emphasizes a predictable, but changing series of communication channels and actors. Unfortunately, these two common metaphors lead researchers and designers alike to take information processing and techno-centric approaches (Frieden, 2005, February 3; Popp, Armour, Senator, & Numrych, 2004) that fail to support the distributed and emergent complexity of situational awareness and decision making in the intelligence domain. A new conceptualization is needed that accounts for the contextual and developmental factors that influence the pluralistic and emergent nature of information, the social and distributed aspects of cognitive activity, and the intuitive, non-logical approach to organizational decision making.

Table 1: Summary of identified cognitive tasks and related CWA constructs.

TASK		STRATEGIES	DOMAIN CHARACTERISTICS	WORKER COMPETENCIES
Down Collection	Target Assessment	-Emerges through traffic monitoring -Assigned from top-down	-Based on multilevel priorities -Temporal changes	-Expertise with target area -Inferential analysis -Determining relevance
	Identification of Priorities and Collection Requirements	-Threat level -Level of authorizing authority	-Consumer and threat dependent -Multiple levels of authority	-Current situation awareness of priorities -Ability to determine and rank priorities
	Tasking Out Collection Requirements	-Use social network -Source Directed Requirement (SOR) -Use formal change of command	-Chain of command response time is 1-7 days -High priorities require circumventing formal chain of command	-Extensive social network -Management skills
	Information Transfer (e.g. collection and/or dissemination)	-Formal report -Intelligence Information Report (can be raw intelligence) -Verbal (face-to-face, phone) -Email, PDA, Online chat room	-Time sensitive -Data security -Information transfer constraints (bandwidth, equipment, availability) -Location constraints (portability, ease of use)	-Rapport with both collectors and consumers -Technology familiarity -Ability to organize information
Conflict and Corroboration	Monitor Traffic	-Emergent pattern assessment -Anomaly detection	-Variations in intelligence type (human reports, imagery, etc.) -High information volume -Inaccurate and incomplete information -Time sensitivity of information -Variances in granularity of information	-High level of domain expertise, context-based situation awareness -Ability to monitor and organize large volumes of information
	Source Validation	-Proximity of information -Level of detail (first-hand knowledge) -Method of information obtainment -Motivation behind information source	-Highly contextual	-Expertise in comparison analysis
	Corroboration of Evidence	-Validate source -Peer review (social network) -Comparison to other reports	-Limited information on source -Reliability and validity of source	-Extensive social network -Domain expertise -Understand context of both the target and the decision maker (or consumer)
Hypothesis Generation	Organization of Information	-Visual representation -Link analysis -Organizational tools (e.g. Excel, Pathfinder)	-Variances in levels of analysis, dynamic and emergent information -Time sensitivity and constraints	-Ability to organize and integrate large volumes of information over time -Ability to track and substantiate analytical process
	Predictive Assessment/Hypothesis Generation	-Link analysis -Brainstorming -Story-telling	-Lack of predictive tools -Time constraints -Changing nature of information -Context sensitivity of information	-Predictive tools -Ability to integrate information -Ability to recognize multiple perspectives
	Development of Formal Report	-Written -Oral Presentation	-Means of information representation -Ability to capture context	-Credible, trustworthy character -Development of social network -Communication skills

A NEW METAPHOR FOR CONCEPTUALIZING INTELLIGENCE ANALYSIS

We posit that the integration between technology, analysts, and the intelligence domain should be modeled after the complexity of weather systems. We challenge the mechanistic and information processing views and instead emphasize an emergent and situated process of information development and decision making.

Radically different than that of even a decade ago, a new global paradigm of intelligence analysis has arisen as a function of the changing quality of the domain illustrated in the threat against U.S. domestic and foreign interests and the transformations enacted by advancing technology. The perspective of the work domain as a distributed cognitive system is exemplified by the distribution of cognitive activities across a dynamic landscape of people and technology. Here, sense-making happens in context, where situational awareness is an emergent state. Decision making – though still hierarchically organized due to the U.S. military influence – is increasingly being pushed down to lower levels in the organizational structure, implying a change in the traditional communication channels and often resulting in a convergence of actors that are topically, temporally and spatially unique. In this way, today's U.S. intelligence system more closely resembles the complexity of weather systems, where elements form discretely and then slowly merge together into a swirling rage that may, or may not, erupt into a devastating storm. This metaphor acknowledges the importance of individual elements, but emphasizes that it is in their potential interaction where the real threat lies. As the path of the storm is only an estimate, so too is the trajectory of possible outcomes only a matter of speculation for an intelligence analyst.

Weather systems are an explanation of atmospheric activity at a given time and place. Such is the same for the analyst, where information, by itself, does not necessarily add value. Objective information only exists in a given framework, only *in contrast, collision, and mergence* to other information whose associative value a priori is not well understood and is also under continual change. Modeling the path of thunderstorms, for example, is as much about the location of the warm front as it is about the specific collision of that warm front with a cooler front, where the potential for tornadoes to be spawned by that collision depends on the terrain, wind speeds, temperature differentials and other contextual factors. Unlike the mechanistic and information processing views, information in this case is more than just the transfer and accumulation of the right bits to the right people. Using the weather system metaphor might help system and technology designers focus attention on how information is created and understood at a given time and place, rather than on information collection and analysis per se.

Weather systems are also ruled by the laws of thermodynamics, where the dynamics of pressure gradients, changes in temperature, and the development of storms are all merely energy in motion. The cognitive activity necessary for intelligence work resides not in the sole individual but in the activity and interaction of multiple analysts. Just as heat is energy in transit, multiple analysts converge to create a stream of cognitive activity. This perspective suggests that both researchers and designers need to focus their studies and designs of intelligence work toward supporting activity at the group or team level, with careful consideration of both the existing and potential interaction between groups and teams over time and place.

Researchers and designers alike should also not ignore how these groups are embedded in organizations and global influences, nor analysts' individual differences and skills. Just as macro factors influence weather patterns (e.g. changes in the jet stream) so too does the organization influence the individual. For example, to better perform in a team environment the organization as a whole should look to develop and employ an analyst for his or her skills, not for his or her role. Using the weather system metaphor, no role in a weather system is permanent (e.g. rain plays different roles during a drought than versus a flood). This stands in direct contrast to the mechanistic metaphor where specialization (skillset) is considered with respect to the task (role) and not apart from it. Organizational and technology designers must consider these fundamental shifts when supporting the intelligence community, along with others, as both global and individual factors will shape and constrain the flow of cognitive activity.

The emergent and situated nature of information also implies that technology acts beyond its typical role of "tool" and becomes an inherent component of how information is created and exists. At the eye of the storm is the fusion of perspectives, where technology not only shapes cognition and collaboration (Woods, 1998) but creates how it is interpreted and thus how it exists and develops across time. Technology designers should more carefully consider how technology systems create and share perspectives rather than simply how to deal with the volume and filtering of information. Technology is thus both a tool and a piece of the puzzle.

The chaotic nature of weather systems means that precise and accurate forecasts are impossible, and that predictions become less accurate as the scope, scale, and range of the forecast is extended. Researchers must take this into account when studying how situational awareness develops among analysts and how this impacts decision making, as well as post hoc reviews. Designers, too, must consider the implications of uncertainty in their development of cognitive aids and automated systems. More specifically, the weather system metaphor suggests that additional effort should be placed on designing cognitive aides that improve information *association* rather than information gathering, highlighting context sensitivity (Woods et al., 2002). Knowledge management systems that extract information from the context likewise need to be reconsidered.

Communication channels and decision-making heuristics that underpin current technology-supported systems should also reflect distributed cognitive activity; how situational awareness and decision making is developed and implemented across analysts under different spatial, temporal, and topical conditions. Thus, information sharing tools and decision support systems will require greater focus on supporting the non-logical, intuitive, and somewhat chaotic pathways of information flow and the distributed nature of cognition across social networks and communities. In what appears a more chaotic environment, understanding the construction and perspectives behind an analyst's, or more realistically, a community of analysts' reasoning will be just as important as supporting the development of the predictive assessment.

CONCLUSION

There is a poor fit between commonly used metaphors employed by designers to conceptualize the intelligence domain. Both the mechanistic and the network-centric metaphors model this domain as a predictive set of tasks, undertaken by a known set of actors, with a clear, or at least estimated, path of interaction. Past catastrophic outcomes of the U.S. intelligence community present an imperative for reconceptualizing how researchers and designers understand, interpret, and design the work domain of analysts. In conclusion, we suggest the use of weather systems as a new metaphor for understanding and supporting the intelligence domain for the design and development of cognitive aids, information sharing and knowledge management, and data processing.

This metaphor adequately represents the evolving, situational-dependent nature of information, and moreover emphasizes situational awareness and decision making as a socially and technically distributed activity that is more about interacting complexities of seemingly independent and static task/actor combinations.

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