# Applying the Human Behavior Architecture in the Simulation of a Networked Command, Control and Communication Structure

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## 1. Background

At the 2008 BRIMS conference, we introduced the Human Behavior Architecture (Warwick et al., 2008). The HBA is the culmination of several efforts to integrate task network and cognitive modeling within a unified development and simulation environment (Lebiere et al, 2002; Lebiere, Archer, Warwick and Schunk, 2005; Lebiere, Best, Archer and Warwick 2005). As we described in 2008, the HBA has been developed to effect a deep integration between two modeling approaches that are often, and mistakenly, regarded as incompatible. In fact, both task network models and production-based cognitive architectures are, essentially, systems for representing transitions between discrete states. The HBA thus supports a unified approach to modeling by representing productions as nodes within a "cognitive sub-network" where the production cycle is driven by the same clock and event queue that controls behavior at the task network-level. In this way, cognitive processes, as represented by a reimplementation of the core functionality of the ACT-R cognitive architecture, can be developed directly within the C3TRACE task network modeling environment.

By 2008 we had verified the function of the ACT-R reimplementation against the tutorial models (see: http://act-r.psy.cmu.edu/actr6/) and developed demonstration models to show off the perspicuous relationship between the cognitive and task network components. In the time since, we have been verifying function in more complex models. In particular, we have taken a C3TRACE model that was developed by the Army Research Laboratory to study the flow of communication in a Future Combat System and attempted a "cognitive retrofit." This exercise had several goals. First, it provided a new opportunity to verify HBA function under the load of a very complicated, independently developed task network model. The complexity of the retrofitted model far outstripped any of the previous test models we had developed. Second, we wanted to demonstrate how additional cognitive fidelity could make a marked but plausible impact over the predictions made by the unmodified model. Third, we wanted to see for ourselves what it would be like to work within the unified development environment of the HBA. It is one thing to note that the perceived incompatibility of task network and cognitive modeling is an unfounded prejudice, it is quite another to simultaneously and successfully engage both approaches. Finally, we used this exercise to lay the ground work for further integration work we are currently performing under the Army's Communications-Electronics Research, Development, and Engineering Center THINK Army Technology Objective. This effort will take the integration one level higher, where HBA itself serve as a component to be integrated with social network analysis tools and techniques for assessing team performance.

## 2. Progress to Date and Outstanding Issues

Though we have been nominally successful in meeting all of our goals, this retrofitting exercise has revealed some interesting modeling challenges and has prompted a few modifications to the HBA. First and foremost, the exercise has reminded us how important good debugging tools are. Task network models are, by their very nature, complex while cognitive models can give rise to some very subtle emergent effect. Verifying the behavior that results from potentially emergent effects in a complex model is very difficult and it is nearly impossible once stochastic variability is added to a model. This has led us to modify the HBA to allow more selectable switching of stochastic effects at the task network level and to identify specific output reports that can be used to isolate the effects of the cognitive model within the HBA.

A second, less obvious modification followed from the realization that the inherent parallelism of a task network model leads to a more distributed representation of the modeled human. This makes it harder to specify a single "interface" between the cognitive model of the human and the tasks that the modeled human is performing. The challenge became clear as we tried to develop a cognitive model of message handling. Although the C3TRACE model explicitly represented the different tasks an FCS-enabled operator would perform upon receiving a message, there was no single point in the model where we could "sniff" all off the message traffic destined for that particular operator. This forced us to implement a fairly complicated queuing structure so that we could continually sample and buffer messages flowing in parallel so that they might be processed serially by the cognitive model. Although we have since modified C3TRACE to support an event-driven polling of messages, thereby eliminating the need for the message queuing, this modification does not reduce the inherent tension that exists when reconciling the parallel representation of task activity with the serial execution of a cognitive model.

Finally, as we look toward our ongoing work to integrate the HBA with social network analysis tools and techniques for assessing team performance we confront questions about the usual semantics within an HBA model. The original motivation of the HBA was to support a "cognitive level" of decomposition within a task network model so that we might make better predictions about task times and decision making. In the context social network analysis and team performance, however, the nodes of the network often represent individual actors, rather than the specific task an actor performs. Similarly, the edges in the graph of a social network can represent any number of relationships between nodes, rather than just specifying the flow of control among tasks. Although a task network might bear an obvious resemblance to the graph, serious ambiguities often lurk behind the familiar. As part of our THINK ATO work we have begun to identify specific points of contact between the analysis of a social network or team performance and the predictions that can be made using a task network model.

## 3. An Opportunity to Engage the BRIMS community

Rather than present results or specific recommendations by was of a formal paper presentation, our intent is to display the basic capabilities of the HBA and to discuss some of the foregoing issues and future work with BRIMS attendees. We hope that this dialogue will help us meet some of challenges while simultaneously making practitioners aware of the new possibilities that HBA affords.

## 4. References


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