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HUMAN-CENTERED ENGINEERING

Socio-technical System Monitoring to Support Enhanced C2 Agility

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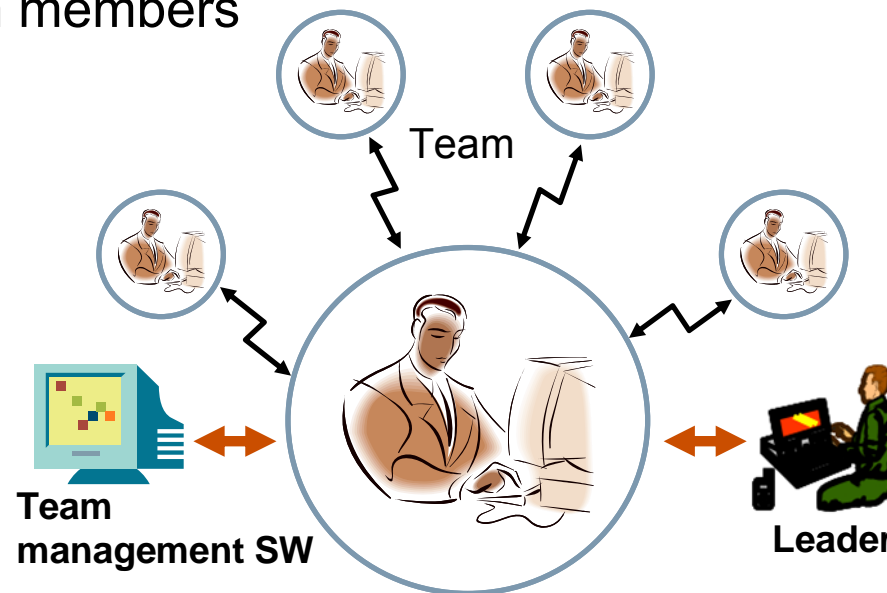
- Motivation
- Problem
- Approach
- Results





Resource Management in Agile C2

- Teams of human operators become involved in missions with ever increasing task complexity and decreasing decision making window
- Agile command and control (C2) organizations are increasing the demands for dynamic network resource management
- This requires real-time determination of operator workflow, which is currently done manually and creates significant burden for the human team members





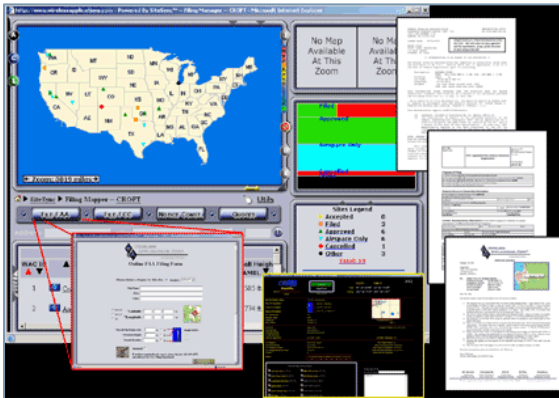
Resource Management Challenges

- “Who is doing what & when”
 - little current status of tasks is available
- “What should be done”
 - little knowledge of what is the right behavior or workflow is known
- “What will be done”
 - no forecasting ability, which is required for good resource management

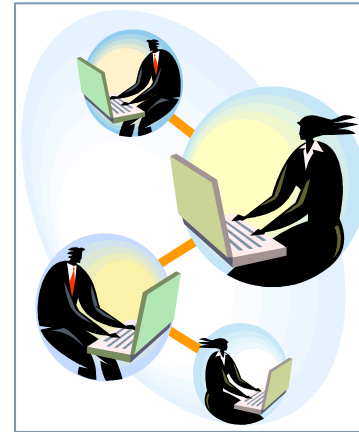


Benefits & Applications

Information Presentation: Highlight dynamic target characteristics such as coordinates, priority, or type while the operator is analyzing this target

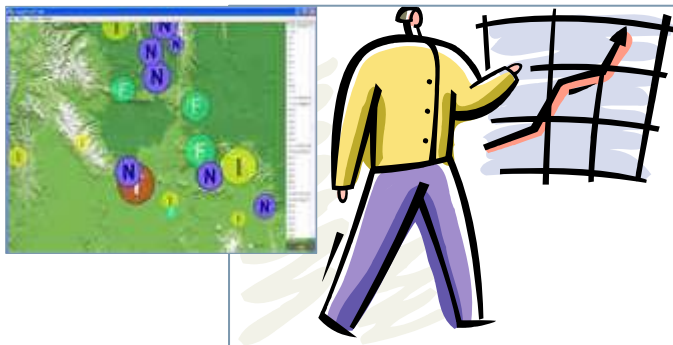


Resource management: Suggest process changes to better distribute work and improve team situational awareness



- Change tasking
- Reallocate roles
- Resource state info
- Connect operators

Taskflow Improvement: Dynamically flag risks in current task execution (deadlines jeopardized or critical tasks overlooked)



Training Enhancement: Develop effective, practical training for new team members based on the ability to give feedback



- Time per task
- Info utilization
- Hand-off
- Resource allocation



- Automated SW for operator behavior pattern learning and classification to support resource management applications
- **Produce:**
 - Patterns of operator and team behavior at different info levels (tasks, activities, events)
 - Estimates of mission, task, and activities performed by team of operators





- Events of **operator-to-application** and **operator-to-operator** interactions
 - Keystrokes and commands issues through UI
 - Applications used
 - Chat and other communications with partial content analysis
 - Products generated

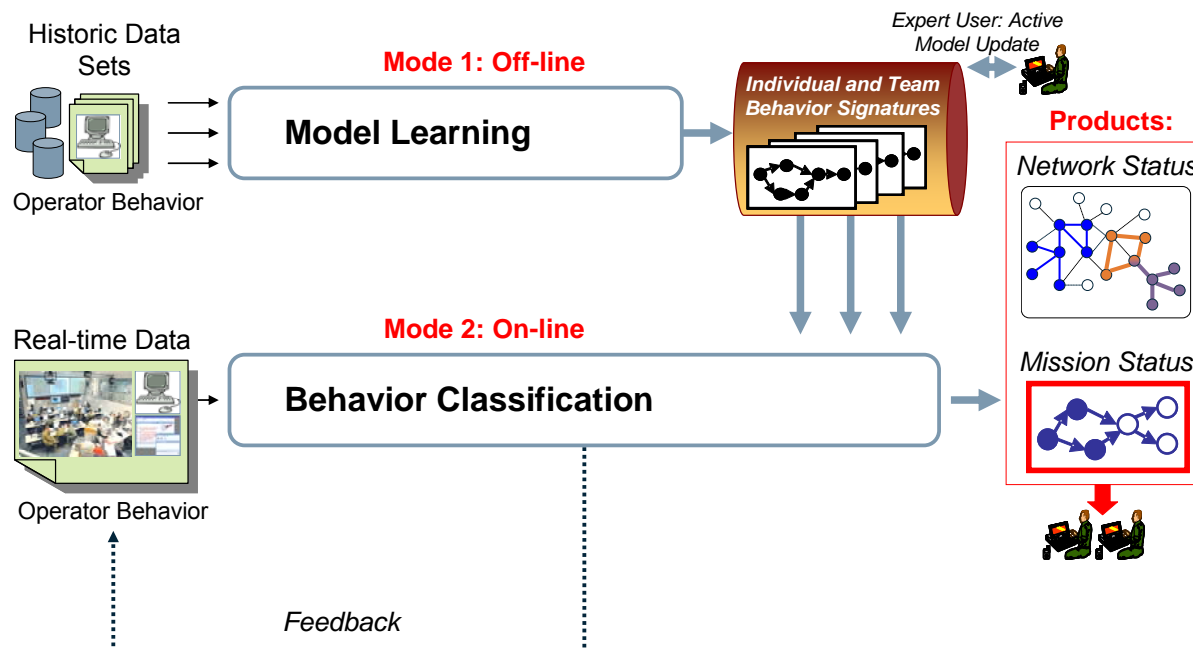
Log:



Time	Event
09:05	open client
09:15	send message to operator A
09:23	conduct target analysis
09:29	communicate target ID & coord
09:37	query task/resource DB
...	
...	

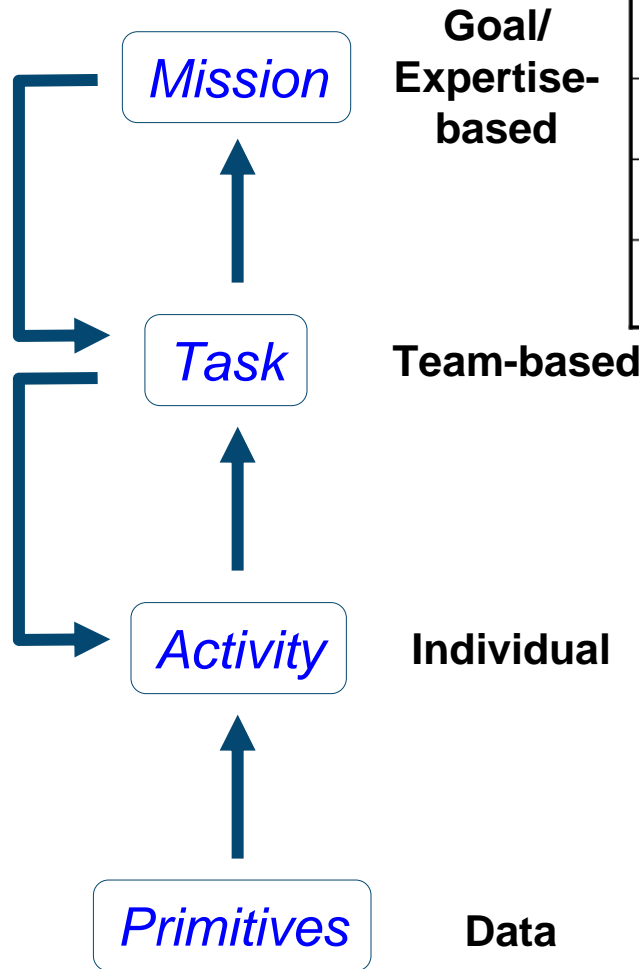


- **Offline: learn** mission-task behavior models
 - Patterns of activities are learned in advance and refined over time
 - Interact with users/experts to attach semantic meaning and edit models
- **Offline: classify** the tasks & missions performed by the team
 - Identify status of network resources and mission

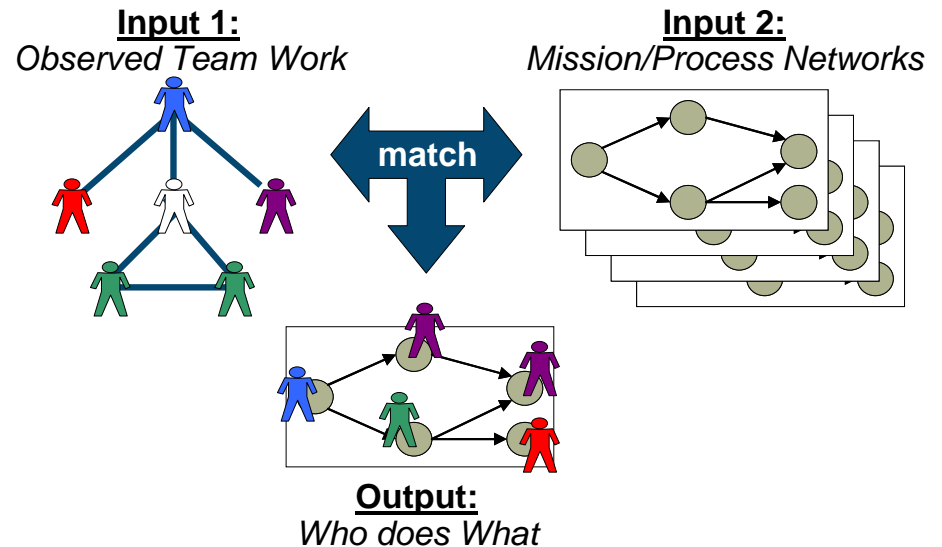




Multi-level Team Behavior-1



Concept	Description	Example 1	Example 2
<i>Role / Mission</i>	Responsibility based on tasks performed	Execute plans and follow ATO	Determine weaponeering options
<i>Task</i>	Mission- & process-level engagement	Attack Target	Assign assets + weapons
<i>Activity</i>	Decisions & actions	Move assets in position	Communicate strike package options
<i>Primitive Action/Event</i>	Keystrokes, comms, used applications	Initiate asset movement Ask state of target	Open comm with DTC

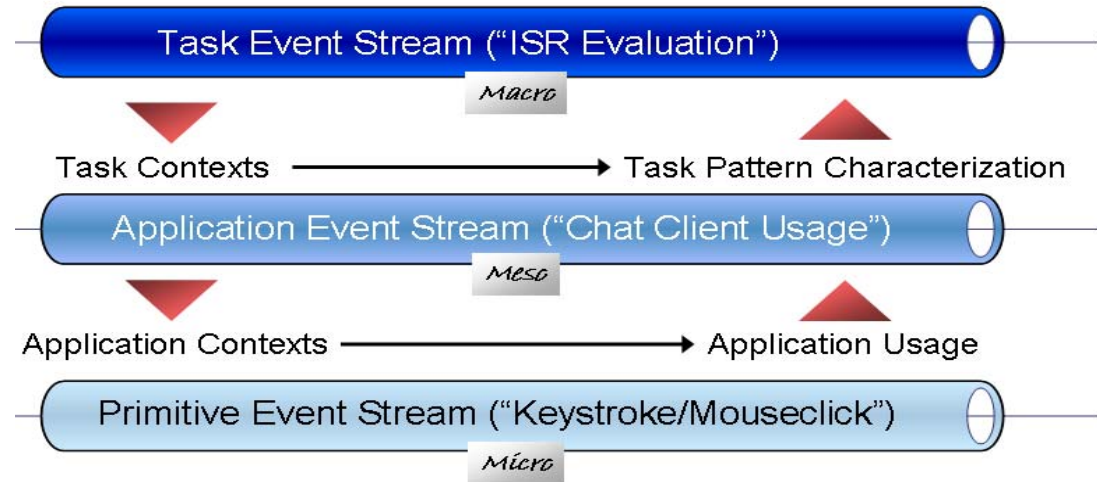




Multi-level Team Behavior-2

At each level

- Context information comes in from the level above
- Hypotheses are formulated and tested against the data at this level
- Results are noted and shared with layers above and below

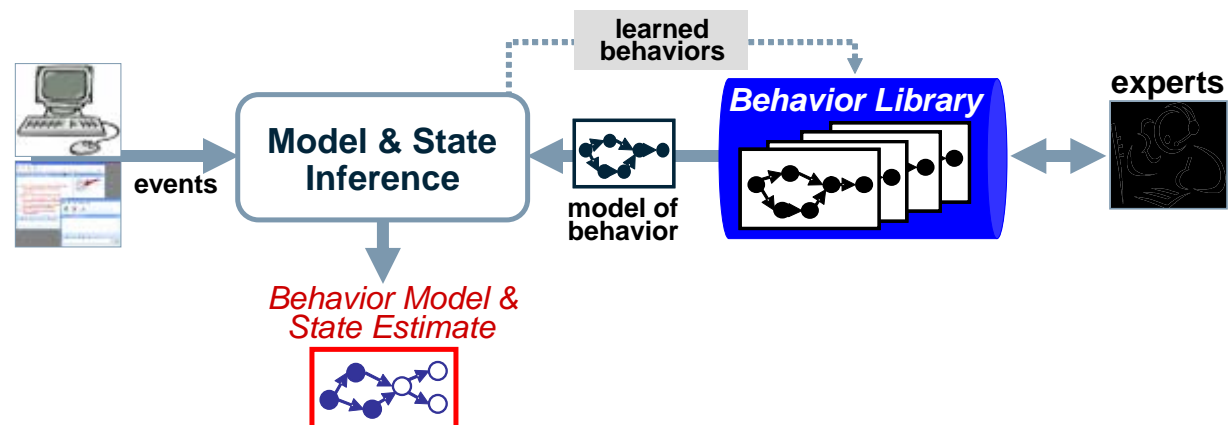


State of the mission

- What is finished?
- Current tasks?
- What is next?

Who is/will be doing what?

- Consider alternative activity patterns for a task





- Tested various structured and unstructured models
 - Hidden Markov Models
 - Probabilistic Latent Variable models
 - N-grams
 - Probabilistic Attributed Network Pattern Matching

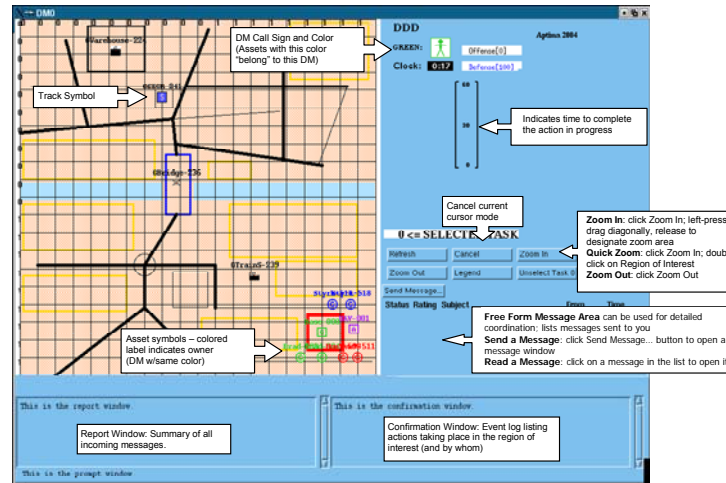
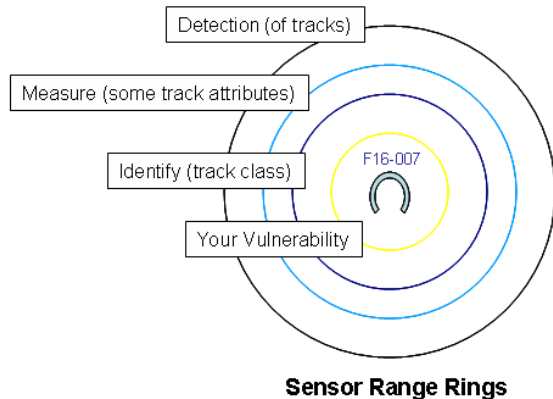
- Assessed model's accuracy and usefulness for the behavior learning and classification applications over several metrics:
 - Inferring latent relationships
 - Handling temporal dependencies
 - Modeling duration
 - Modeling variability in actions and noise in observable data
 - Complexity of learning and classification tasks and corresponding resource requirements

- Algorithm testing employed data from previously run human-in-the-loop experiments involving the AOC DTC

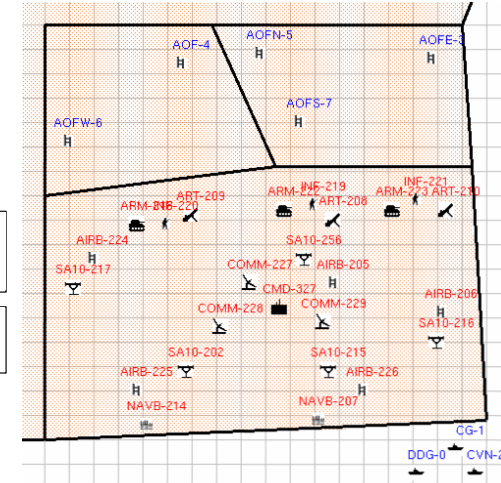


Players/Operators (7 total):

- Intelligence, Surveillance, and Reconnaissance Cell. Ground Track Coordinator
- Attack Coordinator
- Target Duty Officer
- DTC Chief
- Chief of Combat Operations
- Senior Offensive Duty Officer



(a) Example DDD Operator Screen



(b) Initial Battlefield Layout

Setup of experiment:

- # BLUE asset classes and RED target classes - each = 53 (>100 instances)
- BLUE assets:
 - Ships (DDG, CCG, CVN)
 - Helos & airplanes (HH60, F15/16/18, B1B, B2, etc)
 - Sensor airplanes and UAVs (AWCS, Predator, JSTAR, etc.)
- RED targets:
 - Boats, airplanes, ground targets, anti-aircraft sites, tanks



Recap of Classification Accuracy Results

Layer 4: mission



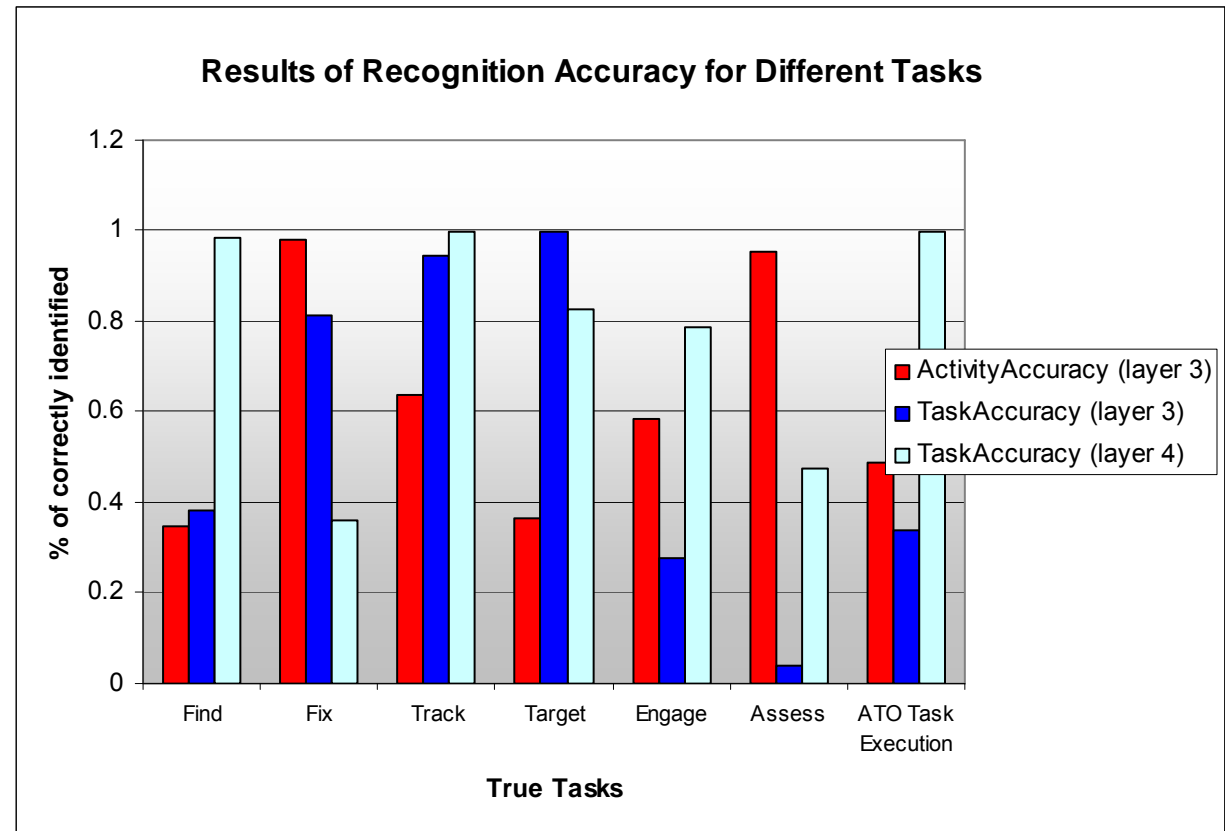
Layer 3: task



Layer 2: activity



Layer 1: event

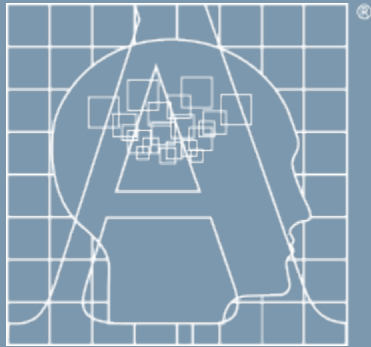


Models:

- ***Layer 3: HMMs (task model with multiple activities)***
- ***Layer 4: Mission mapping (missions consisting of tasks)***



- We presented a multi-level behavior recognition model based on the information hierarchy of data stream and behavior concepts
- The model can learn and track individual and team behavior classes at different levels of granularity
- Using the DTC dataset that contained the ground truth about true activities and tasks of the operators and the overall team, we were able to assess the accuracy of task and workflow recognition algorithms
- While overall recognition accuracy for activities and tasks was high, it did vary by task type
- Future work focus is to develop algorithms to learn temporal and task content structures of team mission workflow from historic team behavior samples



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