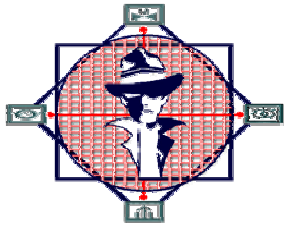

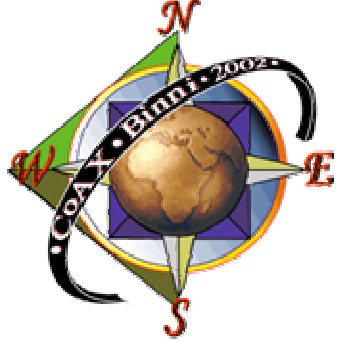

Supporting the Coalition Agents Experiment (CoAX) through the Technology Integration Experiment (TIE) Process

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8th International Command & Control Research and Technology Symposium
Washington, DC.

Presented by
Joshua Walters
ITT Industries

Agenda

- Issues in Coalition Interoperability
- Software Agents
- Multi-Agent System Support for CoAX
- CoAX Storyboard
- CoAX TIE between UTEXAS, NRL and UMD
- UTEXAS AAO and ITE agents
- NRL agent-enabled GCCS-M Surrogate
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Issues in Coalition Interoperability

- Military coalitions are complex organizations that, in many cases, must be rapidly created and effectively managed as the battlefield dynamics change. Issues such as
  - information security
  - interoperability between data and systems across geopolitical boundaries
  - lack of information, and
  - labor-intensive approaches to data collection
- Systems generally exist in stovepipe form, particularly across coalition boundaries, and it is very difficult for them to exchange meaningful data.
- The U.S. Navy's vision of FORCENET is to integrate networks of sensors, weapons, systems and platforms together in order to multiply force power.
  - If this is to become a reality, the integration must be easily accomplished in spite of the barriers that exist in current stovepipe systems.
  - Software agents are being increasingly examined as a potential technology to overcome some of the barriers in making FORCENET a reality, particularly for a coalition command and control environment.

Software Agents

- Agent aided information retrieval and decision support has attracted the attention of the agent research community for several years.
  - Semi-autonomous, intelligent agents working together
  - Emerging as an important model for building the next generation of sophisticated software applications.
  - Appropriate for exploiting diverse, heterogeneous, and distributed on-line information sources,
- Enabling infrastructure for mobile computing
- Interoperability among programs residing at distant sites
- New generations of distributed operating systems, will continue to make the construction of systems based on this model much easier.
- Software agents have been deployed in many commercial, academic, and military domains.

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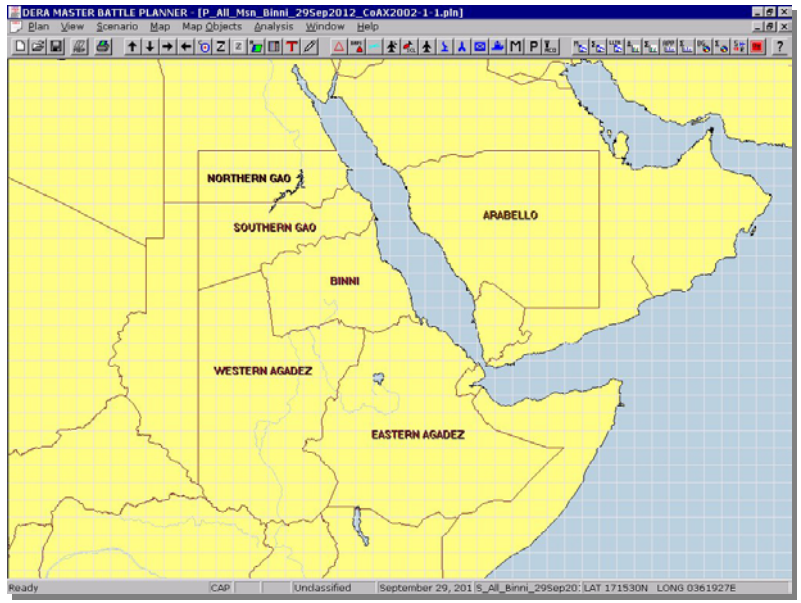
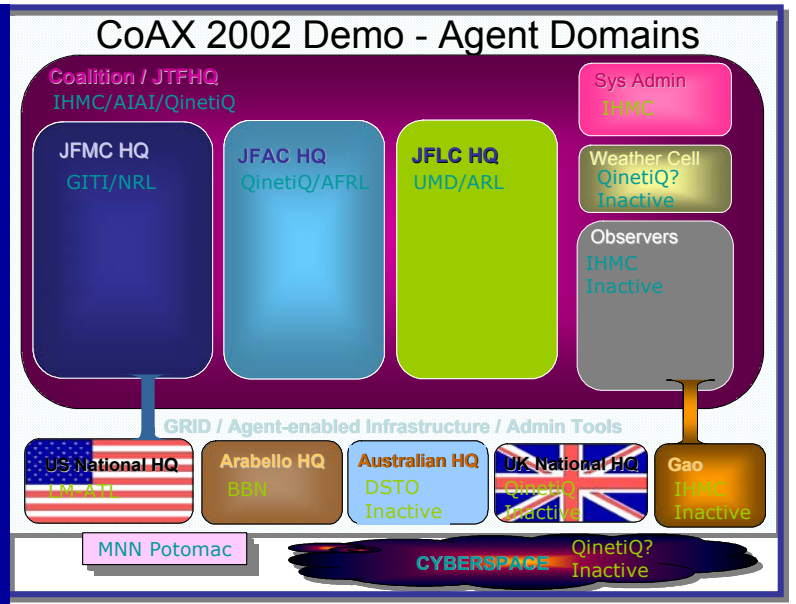
Multi-Agents systems support for CoAX

- DARPA has sponsored the Control of Agent Based Systems (CoABS).
  - The culminating event for CoABS for the Coalition Agents Experiment (CoAX).
  - International collaboration between DARPA, DSTL, DSTO and TTCP as well as DoD laboratories, industry and academia.
- The purpose of CoAX was to demonstrate that multi-agent systems are an effective technology in fostering coalition interoperability
- The scenario chosen for CoAX was based on the TTCP Binni scenario.
  - In the scenario two fictional countries, Agadez and Gao, are in dispute over Binni due to the geopolitical and economic development of this country.
  - From an operational point of view, a coalition is formed to bring peace to the region (and the coalition systems are integrated through software agents).



Multi-Agents System Support for CoAX

- Approximately 70 software agents representing various functional capabilities of the coalition, incorporated into military domains.
  - Each domain contained policies to bound the behavior of the agents according to their role in the domain.
  - Interoperability of agents enhanced through the use of ontology, providing semantic meaning to the information exchanged by the agents.
  - The CoABS grid provided infrastructure to allow agents to register and lookup services.
- The CoAX demonstration was conducted through a series of Technology Integration Experiments (TIE).
  - The purpose of each TIE was to pair up groups based on the synergistic nature of the agent technology provided.



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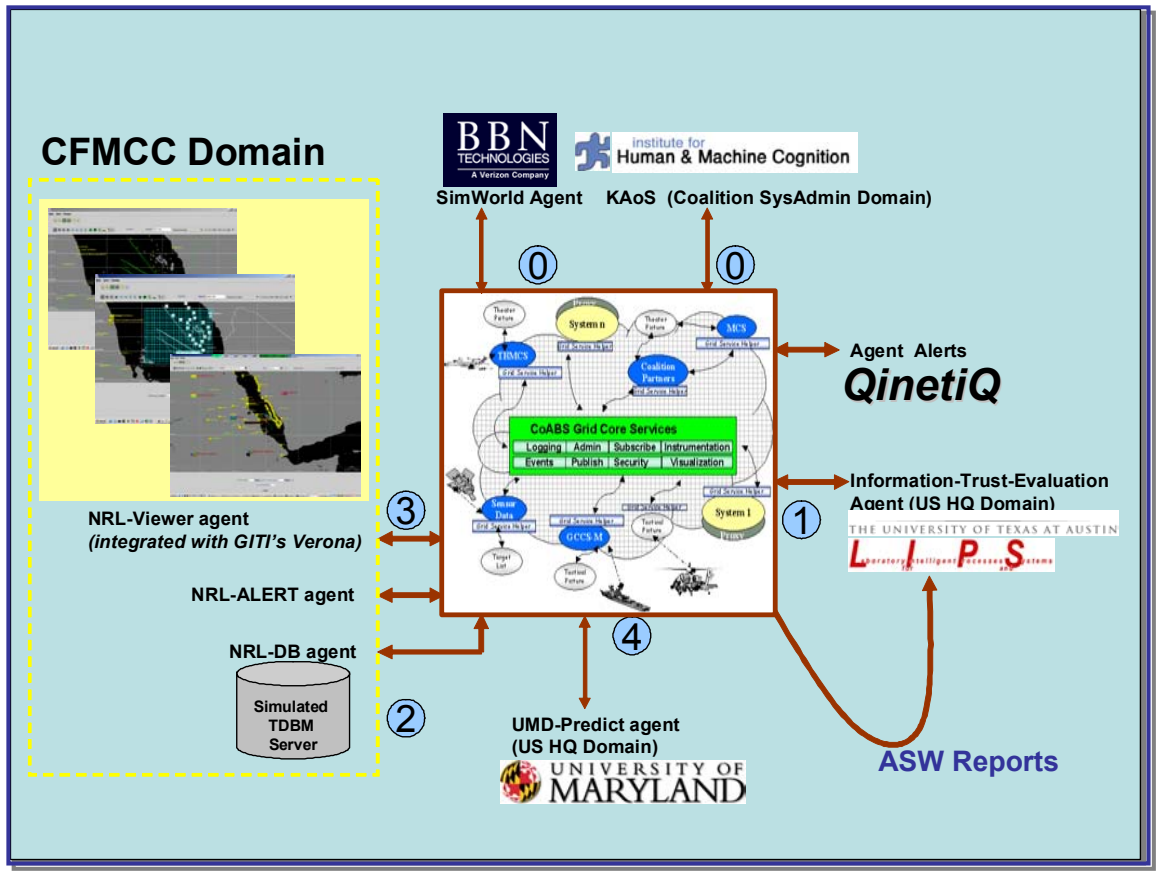
CoAX Storyboard

- The Storyboard was organized in six parts
  - Part 1 demonstrated show how a submarine attack an Australian ship is reported to the Coalition C4ISR through the software agent network;
  - Part 2 demonstrated the collection and distribution of casualty information by mobile agents - enabling timely rescue and treatment;
  - In Part 3, a new country (Arabello), joined the coalition "on-the-fly" (using agents and the CoABS Grid) and provides an information feed from their underwater sensor grid;
  - Part 4 showed the fusion, sharing and employment of the Arabello's underwater array information with the other Coalition ASW forces and sensors *(enabled by Univ. of Texas AAO/ITE agents)*
  - Part 5 demonstrated the Coalition's use of the Arabello information, along with existing Coalition information and tools, to enable countermeasures to be deployed - resulting in a successful end to the conflict. *(enabled by NRL's agent-enabled GCCS-M surrogate and Univ. of MD's UMD-Predict Agent)*
  - Part 6 was a wrap-up. Seeing the resolve of the Coalition forces and the strengthening international support for its operations, Gao and Agadez agree to return to the peace talks conference at the UN.

CoAX TIE between NRL, UMD and UTEXAS

- Purpose of TIE was to demonstrate the capability of tracking and predicting the location of Agadez submarine using intelligent agents
  - NRL (GCCS-M Surrogate)
  - UMD (IMPACT)
  - UTEXAS (AAO and ITE)
- (1) AAO agents requested ASW contact reports from Arabello and ITE agents assigned confidence values (2)
- NRL DB agents then received reports and integrated into surrogate GCCS-M viewer (3)
- Users interacted with surrogate to request predictions on tracks from agents within IMPACT (4)



UTEXAS Adaptive Agent Organization and Information-Trust-Evaluator Agents

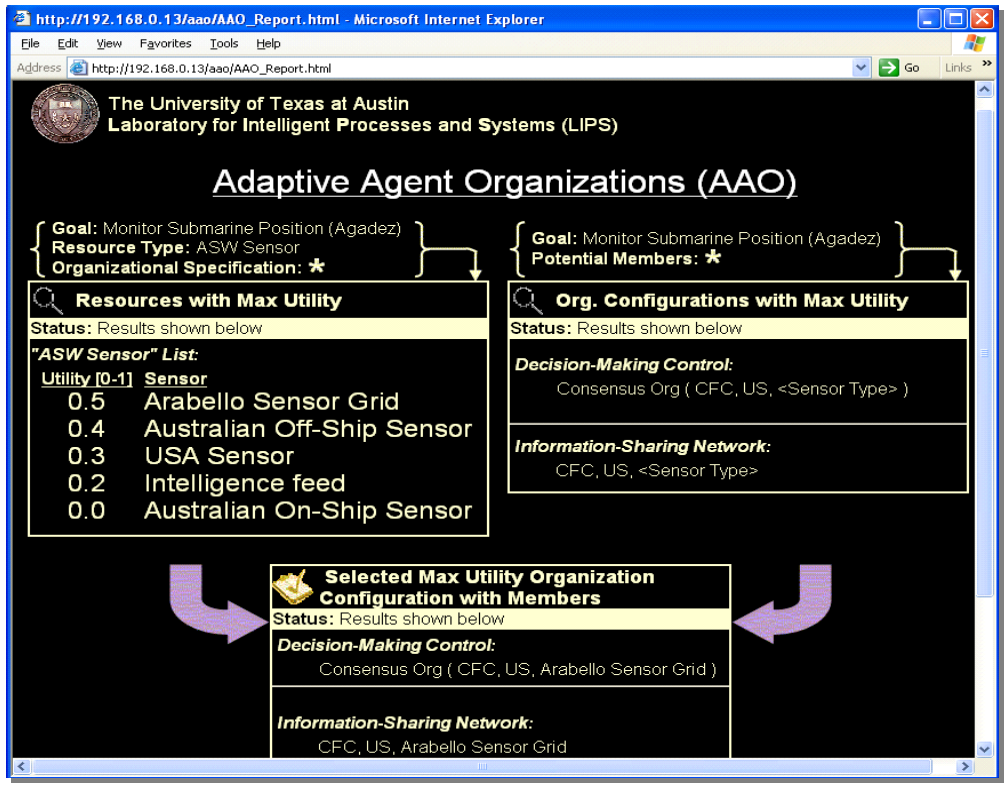
AAO

- The Adaptive Agent Organization (AAO) is designed to support the configuration of a coalition organization
- As this scenario demonstrated, factors affecting mission operations are constantly in flux
  - available assets and capabilities
  - mission plans
  - Threats
  - Deadlines
- The coalition must dynamically adapt in order to respond to those changes.
- The process of configuring coalition organizations involves
  - searching for potential partners
  - evaluating those partners and the resources they offer
  - selecting one or more partners
  - determining the “best” distribution of decision-making control and execution obligations among selected partners working to solve a given problem, and
  - negotiating for and instantiating the proposed organization.

AAO Interaction in the CoAX Scenario

AAO

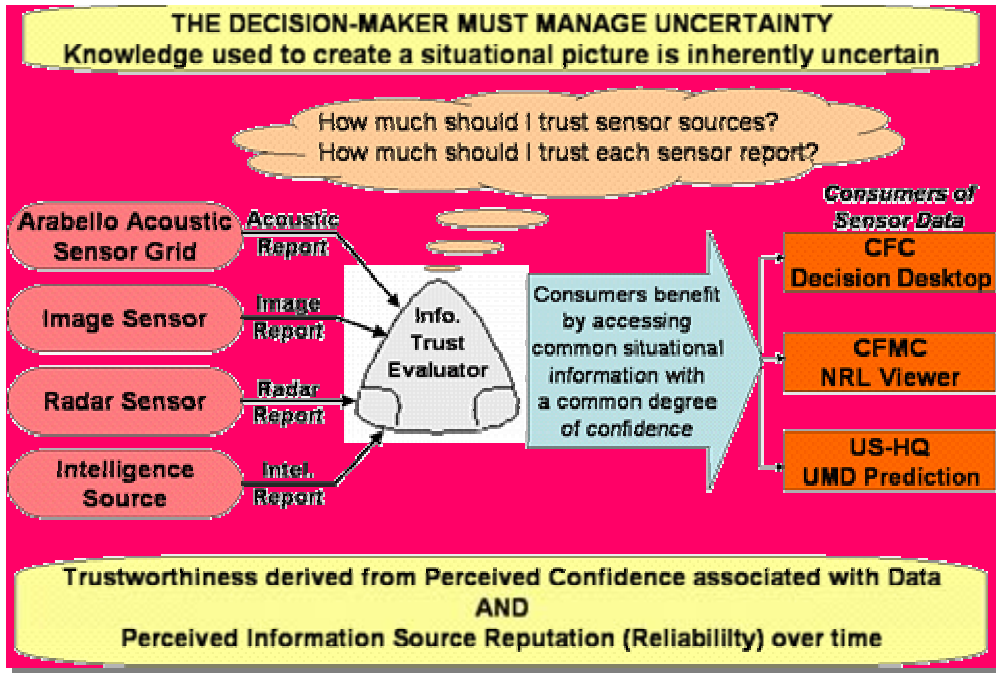
- Identify ASW sensor resources with maximum utility
- Determine the best organization configuration among coalition members:
  - Takes into consideration
    - (i) decision-making control – which members should participate in planning for the submarine monitoring goal and
    - (ii) information-sharing network – which members should have access to information about the submarine's position once the monitoring task begins.
  - Recommend a set of organization configurations with designated members
  - Form the recommended organizations



Information Trust Evaluator (ITE)

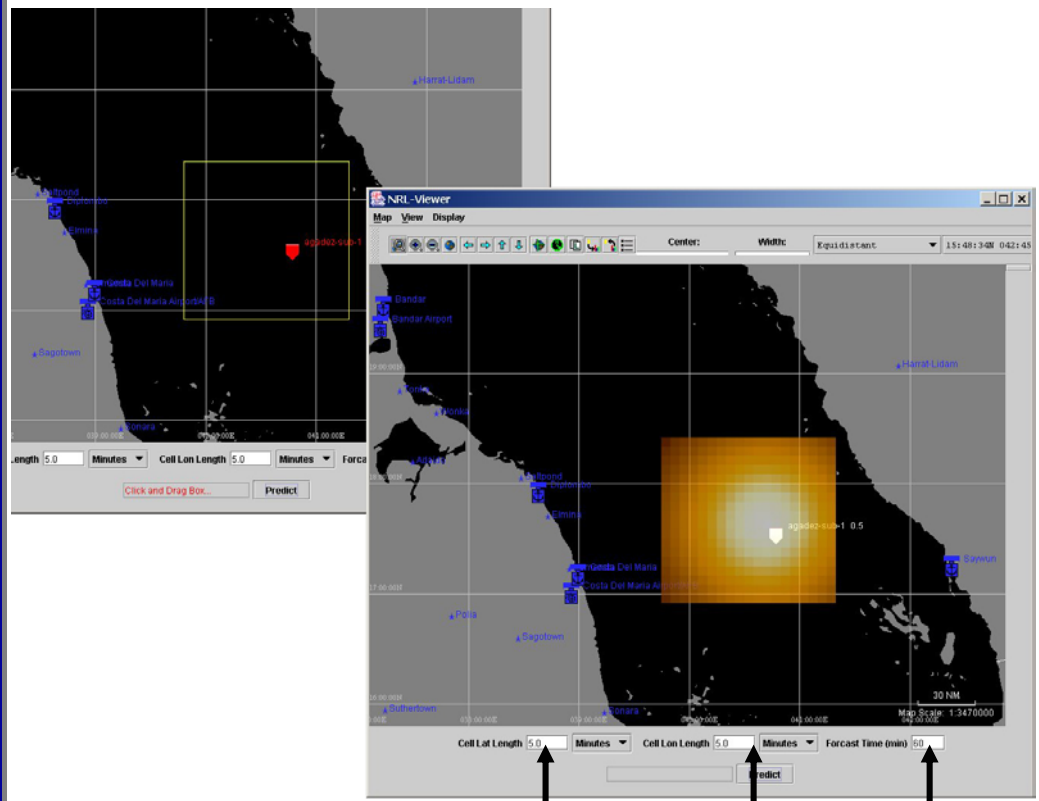
ITE

- The US HQ uses the ITE to help coalesce sensor feeds from multiple sources including Arabello, US and Australia.
- ITE enables this process by creating a "net belief" of the submarine's position for each time stamp reported.
  - Each net belief is created from a collection of related sensor reports
    - each report is qualified by an associated confidence level assigned by the respective source and the source's current "reputation."
  - Source reputations are initialized based on reliability and accuracy.
- The resulting stream of net beliefs becomes the input to
  - UMD agents
  - CFC and CFMCC (i.e., GCCS-M "surrogate") viewers.



NRL Agent-enabled GCCS-M Surrogate

- The NRL participated under the military domain of Coalition Forces Maritime Component Command (CFMCC)
  - The interface demonstrated the manner in which software agents would integrate information into a Navy command and control system.
- ASW contact reports continually received from ITE and stored in simulated track server
- Interacting with the GCCS-M surrogate, a user could
  - Trigger an NRL display agent to communicate with the UMD-Predict agent
  - UMD-Predict specifies future location of the Agadez submarine tracks



UMD-Predict Agent

- UMD-Predict is an agent that benefits from IMPACT's ability to efficiently handle multimedia data such as sensor reports.
- Its forecasts are obtained by
  - generating a large number of prediction models
    - e.g., linear, quadratic and periodic regression
  - combining their estimates into one unified model
    - Weighted averages
  - transforming this model (e.g., by considering terrain and routing information)
  - and then filtering the results (e.g., by constraining the output to the requested time instant and bounding box).
- For CoAX, the results were visualized by the GCCS-M surrogate.

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Summary

- Effectively conducting military operations requires
  - accurate situation assessment
  - ability to quickly adjust and execute plans to respond to the current situational picture.
- In today's geopolitical climate, coalition operations are often the preferred means for responding to international conflicts.
- The CoAX demonstration successfully showed
  - How software agent technology could be used to integrate (sometimes incompatible) systems together
  - The utility of policy and domain management facilities to bound agent behavior and facilitate selective sharing of informatio
  - Ease of composing the agent systems together leading to adaptive responses to changes and unexpected events.

Future Work

- Building upon the CoAX experiment, UTEX researchers are exploring techniques to
  - (i) more accurately calculate the utility of potential members;
  - (ii) ensure scalability when choosing from many possible organization configurations; and
  - (iii) guarantee reliability in the face of possible communication and processing errors.
  - The UTEX researchers focusing on ITE are investigating more advanced reputation representations as well as mechanisms for managing a hybrid of discrete and continuous information.
- The NRL is currently examining the integration of the actual GCCS-M system with the ITEM (Integrated Theatre Engagement Model) simulation via the CoABS grid.
  - The purpose of this integration is to develop and utilize software agents to decompose planning information and efficiently monitor those plans within ITEM.
  - This work is being sponsored by the Defense Modeling and Simulation Office (DMSO).
  - The hypothesis is that agents integrated with both GCCS-M and ITEM will improve the generation of courses of action (COA) and analysis since these agents will help the user to understand the important cause/effect relationships within the plans via simulation.

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