Technology Challenges in Command and Control

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• Lab started in Fall of 1990 as C3 Architectures Lab
• Basic and Applied research
• From 1990-99, all work led to degrees and theses: 5 BS, 13 MS, and 5 PhD degrees awarded; currently 4 PhD
• Since 1999, part of the work has been focused on transitioning technology to Industry and the Government
• Research at the Lab has led to the offering of graduate courses in Discrete Event Systems (ECE 673 / SYST 620) and on the Design of System Architectures (ECE 674 / SYST 621)
• In Fall 2004, a new certificate on Architecture-based Systems Integration will be offered
• Since 1996, specialized short courses on C4ISR architecture design have been offered through AFCEA (over 2000 students from DOD, Intelligence Community and Industry)
Sponsors

• DOD
  – Office of Naval Research (ONR)
  – SPAWAR Systems Center – San Diego
  – Naval Surface Weapons Center (Architecture for base protection from Chem-Bio)
  – Air Force Office of Scientific Research (AFOSR)
  – Air Force Research Laboratory – Information Directorate (AFRL/IF)
  – ASD(C3I) – CCRP; ASD(NII)

• Industry
  – SAIC
  – Raytheon
  – Lockheed Martin
  – Aptima Inc.
  – MITRE
  – AFCEA
Research Themes

• Technology Challenges in Command and Control:
  
  ► Decision Making Organization Design (Command Center Design)
  
  ► Course of Action selection for Effects-based Operations
  
  ► DOD Architecture Design and Evaluation
• Modeling in support of the ONR sponsored “Design-Model-Test-Model” approach for Adaptive Architectures for Command and Control (A2C2 program)

• Development of algorithms and techniques for building and analyzing executable models of organizations using discrete event dynamical systems theory (Colored Petri nets)

• In 2002, cultural attributes were introduced in the models to begin addressing coalition issues in command center design; first paper published

• Current focus: Update and refine software to address some (cultural) issues in coalition command center design
The changing nature of military operations gave rise (1994) to Influence net modeling, a variant of Bayesian nets. SAIC, supported by GMU, developed SIAM (Situational Influence Analysis Model) for DARPA; this has been used extensively by the Intelligence community as well as others.

SIAM is a static model that enables the representation of influences (causes) on a person’s behavior. By stimulating selected influences, one tries to modify that person’s behavior and achieve desired effects.

The Lab has evolved the approach into a dynamic model that includes temporal attributes. It is used to determine Courses of Action for Effects Based Operations (research implementation: GMU’s CAESAR II; operational implementation: AFRL/IF’s CAT).
Course of Action selection for Effects-based Operations

Set of Blue’s potential Actions that will affect Red.

Model Construction → Effects

Desired End States

Time-phased broad actions

Command Intent

Probabilistic model relating actionable events to effects through a network of influencing relationships: Influence Net model

Set of Desired and Undesired Effects

Set of Red’s COAs

May include Red’s COAs

From Red’s Point of View
The Effects Based Operations modeling approach starts with the definition of desirable Effects on the Adversary (Red) and the desired end state of Blue.

Then we work backwards (from right to left) to the Centers of Gravity of Red that influence the desired Effects – the arrows show the “Cause to Effect” relationships (left to right).

Then we identify the Operational Functions of Red that affect the COGs, which in turn influence the Effect(s).

We continue “unfolding” backwards in a “Cause to Effect” chain till we arrive at Actionable Events that can be carried out by Blue.

Finally, we include other external events, not controlled by Blue, that influence the achievement of the desired Effects on Red.

There are also “Cause to Effect” relationships that affect the strength of the influences (e.g., selected Information Operations).
Alternative approaches and tools can be used to design the C4ISR Architecture views.

Two six stage processes have been developed in the Lab for designing architectures conformant to the DOD AF:
- Structured Analysis approach
- Object Oriented approach

An executable model is derived based on the information contained in the static views and is used for architecture evaluation.
System Architectures Lab

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