



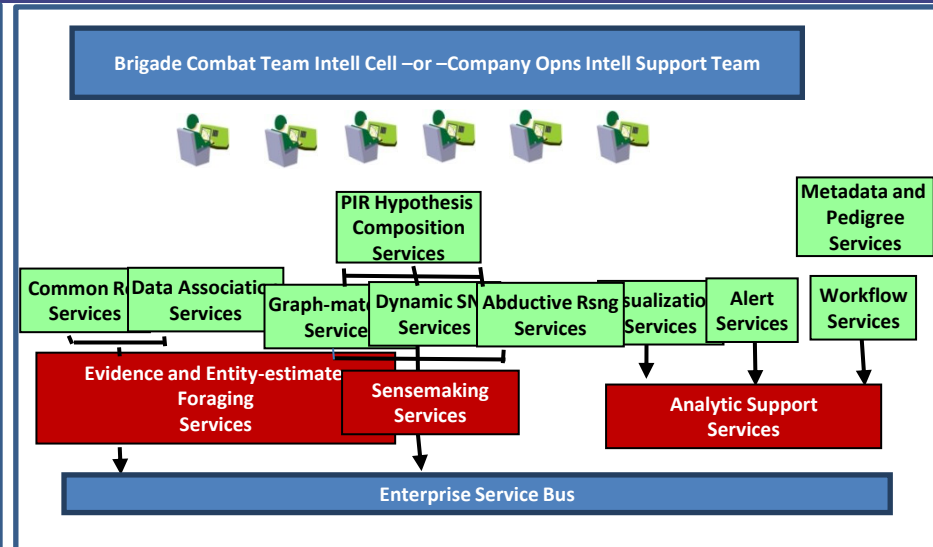
# Task 9: Studies of Technology Concepts of Employment.

## Jim Llinas



### Objectives

- **Basis for Effectiveness/Operational Value Assessment** for most Information Fusion/AI technologies
- **Framework for:**
  - **Architectural Design:** fit of IF software to Operational Infrastructure—critical Interfaces, standards compliance, etc
    - Main driver for defining the **human role**
  - Understanding and addressing **Operational Reqmts** imputed onto IF design—eg nature of Actionable Intelligence, OpTempo (OOSM), Predictive Reqmts, HCI and Visualization, etc
  - **Technology Transition**, to 6.3 type Army programs



### Technical Approach

- Literature Review
  - Various Army Docs and Open Source
- Limited discussion with Army SME (e.g., Walsh)
- Deeper technical analysis re Reasoning, Discovery, Learning, and Hypothesis Composition techniques

### Accomplishments

- Evolving but document-based understanding of BCT/IC and COIST COE
- Evolving architectural and functional framework for user support

### Challenges

- Deeper, real-world understanding of COE's
- Practical designs and implementations of:
  - Foraging function
  - Hypothesis Composition
  - Visualization
- Support to T&E design and plan

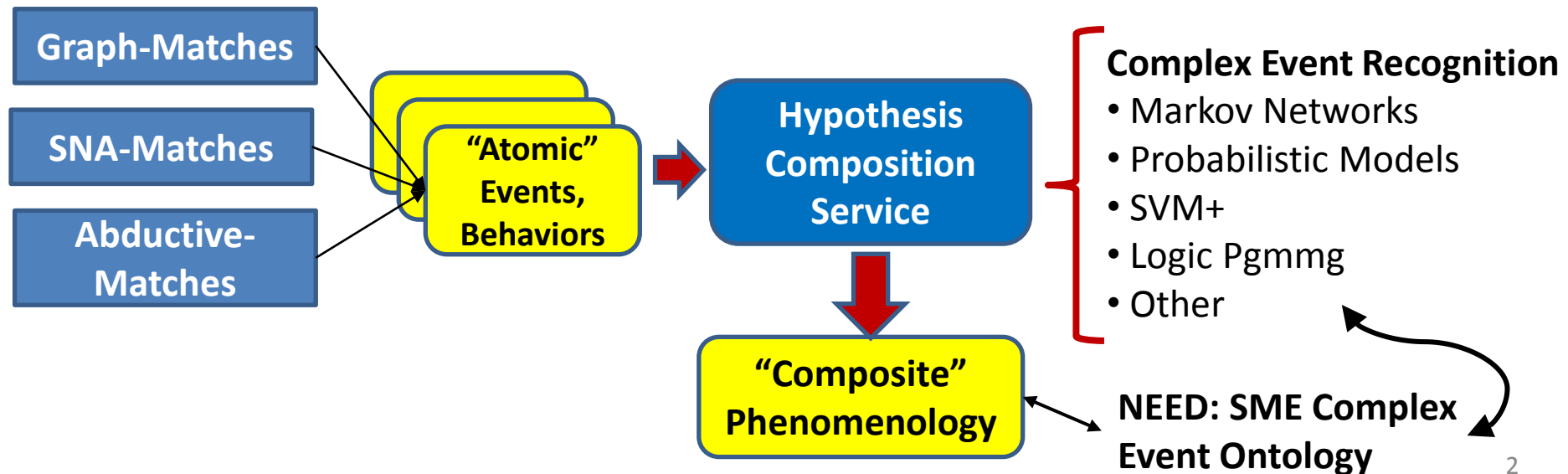


# Main Scientific/Technical Accomplishments

## Studies of Technology Concepts of Employment



- Rationalization of Discovery/Learning-based Approach to User Support: Limited a Priori Deductive Knowledge

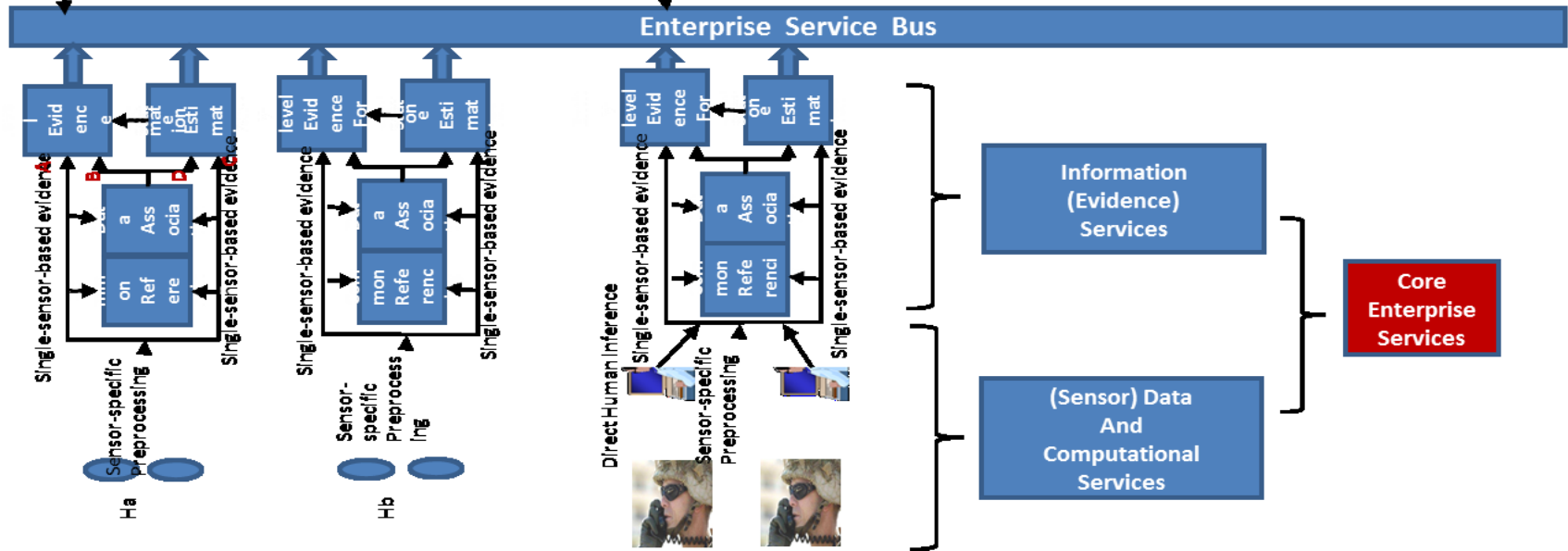
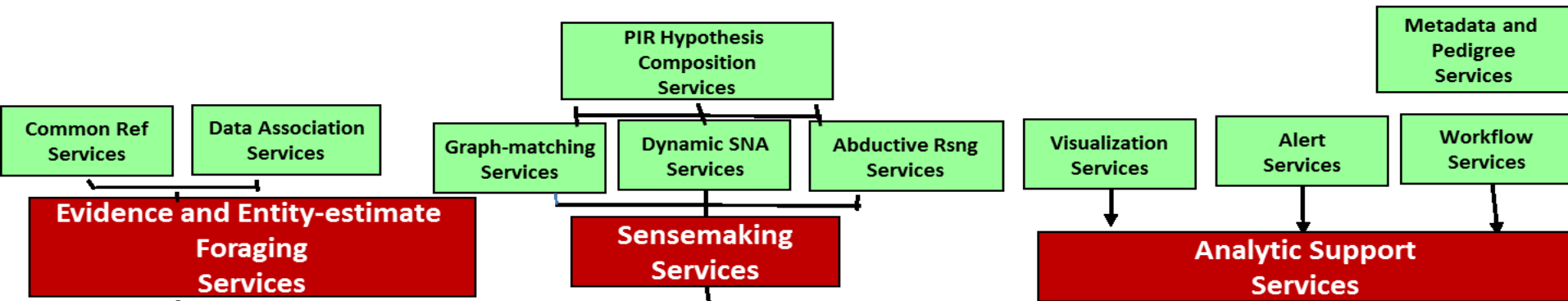




# Analysis/Decision Support Architectural Design



Brigade Combat Team Intel Cell –or –Company Opns Intel Support Team



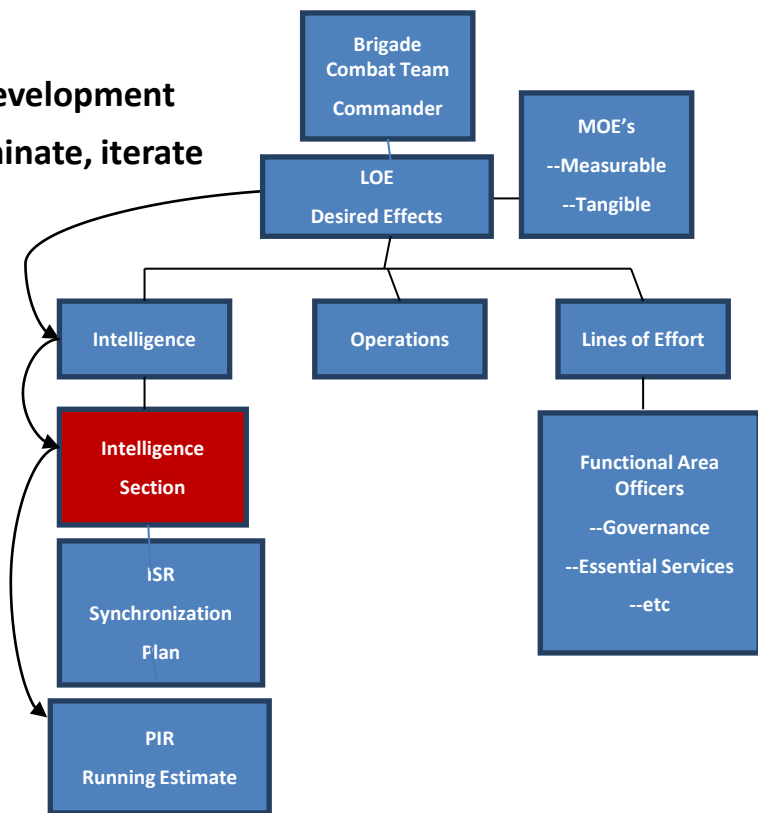


# Nominal Users and Differences in Requirements



## Brigade Combat Team Context (3000-5000 Soldiers)

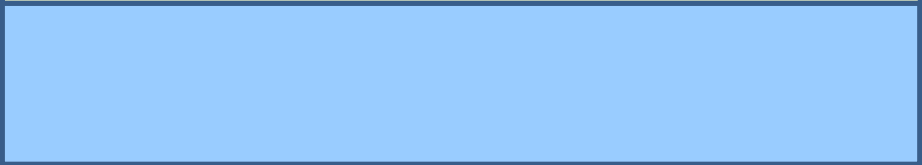
PIR Development  
--Nominate, iterate



## Company Operations Intelligence Support Team (COIST) Context

Outgoing patrols are briefed on the following

- **Current threat** assessment for the Area of Operations with regard to **significant activities in the last 24 hours.**
- Current IED threats and locations of concentrated IED attacks.
- Enemy activity expectations for the next 24 hours. **(Predictive Analysis)**
- Current HVI list with pictures if possible.
- Information requirements



“The only mission of the Intelligence Section is to answer the commander’s PIR “



## Publications and Briefings



Rimland, J.C. and Llinas, J., “Network and Infrastructure Considerations for Hard and Soft Information Fusion Processes”, Proc. Intl Conf on Information Fusion, Singapore, July 2012

Llinas, J., Crassidis, J., and Sudit, M., “Sensor, Data, and Information Fusion: Facing Modern Challenges”, Seminar to the NRO, March 30, 2012

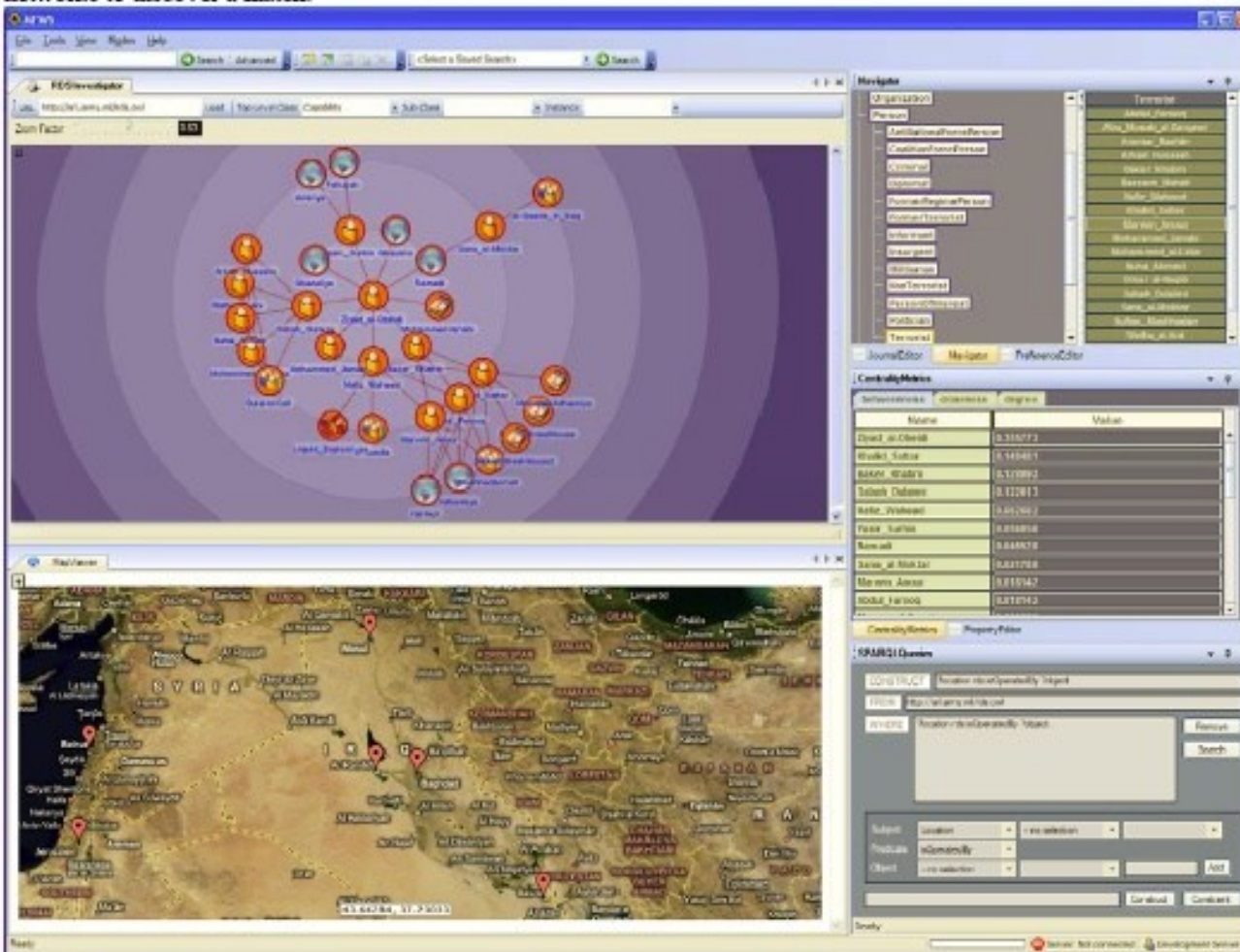
Llinas, J., “Algorithmic, Architectural, and Employment Concept Challenges Presented by the Hard + Soft Data Fusion Problem”, Canadian Tracking and Fusion Group Workshop, Ottawa, CA, Sept. 2012

Llinas, J., “Challenges of Fusing Hard and Soft Data: The Nature of the Fundamental Process and One Current Approach”, to be presented at the NRO Science of Multi-INT Conf., Sept. 2012

Llinas, J., Nagi, R., Duff, D., Patel, M., and Walsh, D., “Framing and Defining New Fusion Strategies and Advanced Analytics for Relation-driven Problem Environments”, to be presented At the Natl Symp on Sensor and Data Fusion (NSSDF), Oct. 2012



# Technology Transition 1: Graph-Matching Discovery/Learning Tool Prototype



**Army Research  
Lab  
6.2 Development  
Aberdeen  
Proving Grounds**

**CMIF  
Graph-matching  
Algorithm  
(Web Applet)**

Figure 2: Prototype Analyst Workstation



# Technology Transition 2: Uncertainty Alignment Engine



## Objectives:

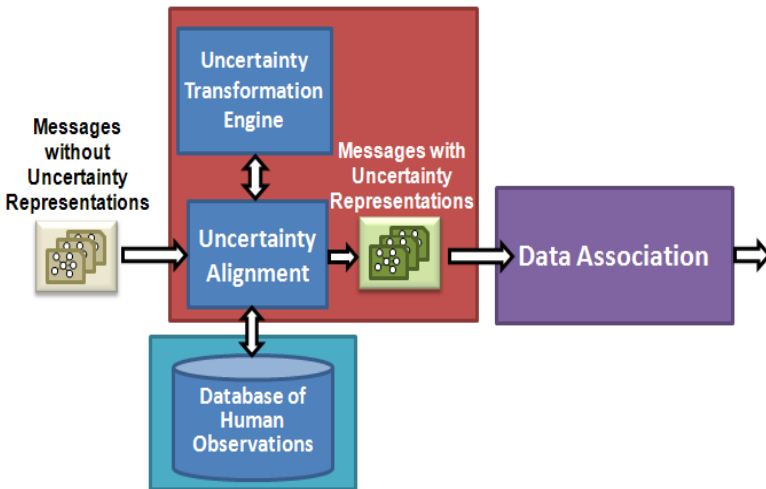
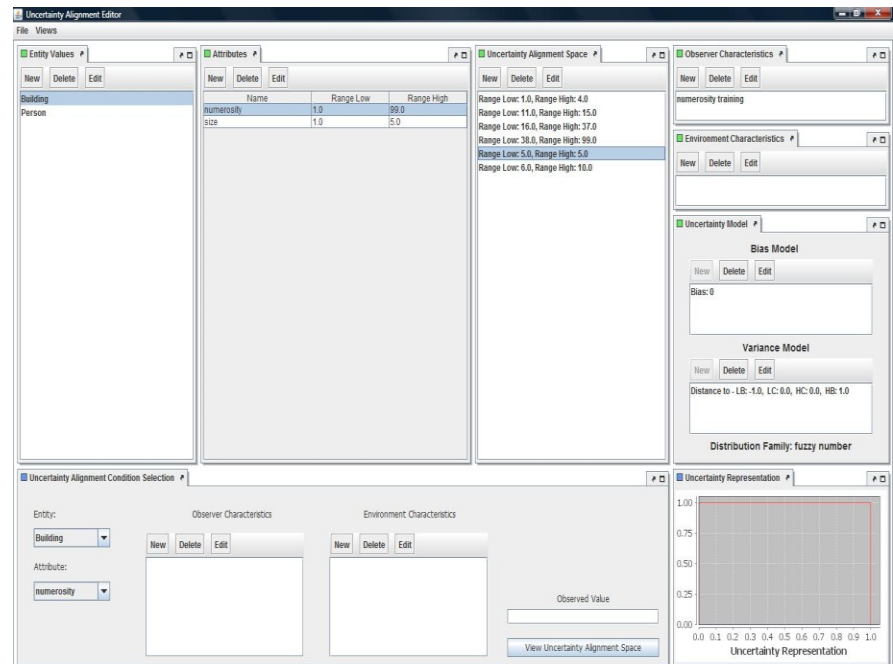
- Align observations with consideration for observational uncertainties
  - Assess observational biases/variances
- Possibility-Probability Xforms

## DOD Program Benefit:

- Uncertainty alignment enables accurate uncertainty propagation through situation assessment process

**Army Research  
Lab  
6.2 Development  
Aberdeen  
Proving Grounds**

## Initial Prototype Tool HCI



## Process Architecture



# Technology Transition 3: SYNCOIN Data Set

## Description

- Counter-Insurgency (COIN) scenario in Bagdad and contains synthetic soft (human report) data, synthetic hard (physical sensor) data, and real hard data collected using human-in-the-loop vignettes collected at a special facility in central Pennsylvania.
  - 600 soft messages
  - Hard messages flexible if synthetic
  - Hard messages IAW taxonomy of events if based on real data

## DOD Program Benefit:

- Truthed and operationally realistic research data set provides a flexible, adjustable data set for algorithm development that permits testing and evaluation

## Provided to many organizations:

- **ARL Tactical Fusion Branch**
- **ARO Network Science CTA**
- **AFRL/SNAA**
- **Army I2WD**
- **Spawar Systems Ctr**
- **Qinetic**
- **BAESystems**
- **Raytheon**
- **Stottler-Henke**
- **Aptima**
- **UCONN**
- **UMiami**



# Technology Transition 4:

## Map-reduce Version of Association Engine



### Description

- To handle large quantities of entity observations, the Lagrangian heuristic for Graph Association is adapted for the multidimensional assignment problem and implemented in a map-reduce framework.

### DOD Program Benefit:

- Transition to 6.3 Pre-DCGS-A transition environment for ablation testing for possible consideration for DCGS-A
- Possible use on Knowledge Discovery and Dissemination program at IARPA

### Lagrangian Relaxation of $GA^N$

Dualize the triangle constraints, which enforce transitivity when handling more than 2 graphs:

$$GA^L = \max \sum_{(G_m, G_n) \in \binom{\mathcal{G}}{2}} \left( \sum_{v_i^m \in V_m} \sum_{v_j^n \in V_n} w_{ij}^y x_{ij} + \sum_{e_{ik}^m \in E_m} \sum_{e_{jl}^n \in E_n} w_{ijkl}^e y_{ijkl} \right) + \sum_{(v_i^m, v_j^n, v_k^p) \in \mathcal{P}^V} \theta_{ijk}^y (x_{jk} + 1 - x_{ij} - x_{ik}) + \sum_{(e_{ij}^m, e_{kl}^n, e_{mn}^p) \in \mathcal{P}^E} \theta_{ijklmn}^e (y_{ikmn} + 1 - y_{ijkl} - y_{ijmn})$$

$$\text{subject to: } \sum_{v_i^m \in V_m} x_{ij} \leq 1 \quad \forall v_j^n \in V_n, G_n \in \mathcal{G}, G_m \in \mathcal{G} \setminus G_n$$

$$2y_{ijkl} \leq x_{ij} + x_{kl} + x_{il} + x_{kj} \quad \forall y_{ijkl} \in E_m \times E_n, (G_m, G_n) \in \binom{\mathcal{G}}{2}$$

$$y_{ijkl}, x_{ij} \in \{0, 1\}$$

Can solve using subgradient method.  $(x_{jk} + 1 - x_{ij} - x_{ik})$  is the gradient at  $\mathbf{x}$ .

**Provided to :**

- IARPA**
- Army I2WD (A2SF Program)**

See: Gregory Tauer and Rakesh Nagi. A Map-Reduce Lagrangian Heuristic for Multidimensional Assignment Problems with Decomposable Costs. Under Review, submitted to Parallel Computing. 2012.