Data Fusion & Resource Management (DF&RM) Dual Node Network (DNN) Technical Architecture

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July 2020
Briefing Objectives

• Provide an understanding of the roles for Data Fusion & Resource Management (DF&RM)

• Describe how the Data Fusion heritage can be used to “jump-start” dual Resource Management solutions

• Describe DF&RM Dual Node Network (DNN) Technical Architecture
Fusion & Management Lie in the Gap Between “Observe” and “Act”

- **Data Fusion** is the process of combining data/information to estimate or predict the state of some aspect of the world.
- **Resource Management** is the process of planning/controlling response capabilities to meet mission objectives.
Sensor Fusion Exploits Sensor Commonalities and Differences

Data Association Uses Overlapping Sensor Capabilities so that State Estimation Can Exploit their Synergies
Resource Management Exploits Sensor Commonalities & Differences

Sensor Task Planning Uses Overlapping Sensor Capabilities so that Control Can Exploit their Synergies
2004 Revision of the Joint Director’s Lab Data Fusion Model

DATA FUSION DOMAIN

Level 0 Processing
SIGNAL/FEATURE ASSESSMENT

Level 1 Processing
ENTITY ASSESSMENT

Level 2 Processing
SITUATION ASSESSMENT

Level 3 Processing
IMPACT ASSESSMENT

Level 4 Processing
SYSTEM ASSESSMENT

Database Management System

Support Database
Fusion Database

Sources

INTEL EW
SONAR RADAR
Data bases

Local

Distributed

Resource Mgmt

Human/Computer Interface
Architectures are frequently used mechanisms to address a broad range of common requirements to achieve interoperability and affordability objectives.

An architecture (IEEE definition) is a structure of components, their relationships, and the principles and guidelines governing their design and evolution over time.

An architecture should:

- Identify a focused purpose with sufficient breadth to achieve affordability objectives
- Facilitate user understanding/communication
- Permit comparison, integration, and interoperability
- Promote expandability, modularity, and reusability
- Achieve most useful results with least cost of development
• The operational architecture provides the “what and who” operational needs
• The technical architecture provides “problem-to-solution space” guidance
• The systems architecture defines the “how” to build the operational system
Data Mining Learning of Fusion Models

- Data Mining discovers and models some aspect of data input to each fusion level
- Data Fusion combines data to estimate/predict the desired state at each fusion level
Fusion Network Selected to Balance Performance & Complexity

- Single Platform
- Single Sensor
- Single Time
- Single Data Type

Least Complex Tree

Knee-of-the Curve Fusion Tree

Best Performance Tree

All Platforms
All Sensors/Sources
All Past Times
All Data Types

Data Fusion Performance

Data Fusion Cost/Complexity

“Knee of Curve” Design
DF&RM Trees Divide & Conquer the Problem

Centralized

Hierarchical

- Fusion tree defines batching of data by
  - Sensor/source
  - Past time
  - Datatype

- Management tree defines batching of commands by
  - Resource (sensor or response)
  - Time horizon
  - Command type

Data Fusion Trees

Resource Management Trees

- High performance
- High complexity/cost

- Sufficient performance
- Reduced complexity/cost

Each node in each tree generates, evaluates, and selects solutions for knee-of-the-curve performance vs. cost.
DF/RM Duality Allows Similar Approaches & Consistent Operation

**DATA FUSION**

**Fusion Architecture**
- "Fan-in" Tree
- Data batching by source, past time or data type

**Association**
- Exploit overlapping measurement observables
- Generate, evaluate & select association hypotheses

**Estimation**
- Exploit independent measurement observables
- Use associations w/ a priori parameters to compute estimates

**RESOURCE MGMT**

**Management Architecture**
- "Fan-out" Tree
- Task batching by resource, time horizon or command type

**Response Planning**
- Exploit overlapping resource capabilities
- Generate, evaluate & select response plans

**Control**
- Exploit independent resource capabilities
- Use assignments w/ performance parameters to compute control
DF & RM Node Duality Facilitates Understanding of Alternatives & Reuse

DATA FUSION NODE

- Sources & Prior DF Nodes
- DATA PREPARATION (Common Referencing)
- DATA ASSOCIATION
  - HYPOTHESIS GENERATION
  - HYPOTHESIS EVALUATION
  - HYPOTHESIS SELECTION
- STATE ESTIMATION & PREDICTION
- RESOURCE MGT CONTROLS & DF NEEDS

RESOURCE MANAGEMENT NODE

- User or Prior RM Node
- TASK PREPARATION (Common Referencing)
- RESPONSE TASK PLANNING
  - PLAN GENERATION
  - PLAN EVALUATION
  - PLAN SELECTION
- PLAN TASKING/CONTROL

RM NEEDS & DATA FUSION ESTIMATES

SENSOR STATUS

RESPONSE TASK PLANNING

RESOURCE STATUS
Sample Interlaced Network of DF&RM Dual Level Interactions

**Data Fusion Node Network**

- Level 0: Feature Assessment
- Level 1: Entity Assessment
- Level 2: Situation Assessment
- Level 3: Impact Assessment
- Level 4: System Assessment

**Resource Management Node Network**

- Level 0: Resource Signal Management
- Level 1: Resource Response Management
- Level 2: Resource Relationship Management
- Level 3: Mission Objective Management
- Level 4: System Management

**DF&RM Reactive Loop**

User I/O (at all levels as needed)