Agent Technology for Intelligent Decision Support Systems

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Lead Member Engineering Staff
• Our mission …
  – Solve world class information technology problems
  – Provide a consistent stream of technology discriminators for Lockheed Martin businesses

• Our formula …
  – Advanced technology
    • Innovation in advanced computing and intelligent software
    • Exploitation and hardening of emerging technologies
  + Domain expertise
  + Path to a product
    • Integrated solutions with quantified payoff
    • Proven technology transition

• … leads to paradigm-changing payoffs
So What’s An Agent?

A lightweight, autonomous (but controllable), mobile software process that carries out tasks ...

... that can process functions it carries or "docks" with ...

... over tactical networks (e.g. radios) of varying bandwidths
Agents act autonomously to accomplish objectives.
- Goal-Directed
- Knowledgeable
- Persistent
- Proactive & Reactive

Agents cooperate to achieve common goals.
- Communication Protocols
- Knowledge-Sharing
- Coordination Strategies
- Negotiation Protocols

Agents adapt to their environment.
- Dynamic Interaction
- Alternate Methods
- Machine Learning

Agents can be either static or mobile, depending on bandwidth requirements, data vs. program size, communication latency, and network stability.
Strengths of EMAA-based Systems

• Reusability
• Bandwidth management
• Security
• Ad hoc networking/Reconfigurable Architectures
Foundation: ATL’s Extensible Mobile Agent Architecture (EMAA)

- Docks reside on network nodes; manage agents and servers
- Agents provide dynamic execution control of user tasks
- Servers provide processing capability and access to databases, Web, email, ...

EMAA is ATL’s solution to foster rapidly developed, easy to maintain agent applications
EMAA Mobile Agents

- A mobile agent’s goal is to complete its itinerary
- Itinerary: A Work Flow Specification
  - Activity: Agent Tasks @ Location
  - Path: Reactive Branching Behavior, Agent Travel
  - Shared Internal Memory for loose task coupling
- Dock Servers wrap system resources
  - legacy applications
  - operational data sources
  - computational engines or services
• Servers provide interface to local resources
  – Separates implementation of resources from agent application
  – Reduces bandwidth requirements of individual agents
  – Improves security and resource access control
  – Improves resource management capability

• Tasks allow agent to utilize servers
  – A task represents a use case of the server.
  – Parameterized for reusability
  – Able to fetch operational parameters from agent memory
  • no tight coupling between tasks
  • data shared through agent memory component
**Objective:** Framework to support agents adaptively selecting an execution path at run time, considering the relative priorities of different itinerary paths and network conditions.

EMAA agents are effective at achieving their goals by selecting the most important activity to perform at the most appropriate host.
Intelligent Decision Support Key Factors: Speed and Coordination

- Operational speed depends on:
  - Exploiting information as soon as it is available
  - Exploiting all information
  - Speed of analysis and synthesis of information
  - Adapting to variables

- Operational coordination depends on:
  - Shared situation awareness
  - Collaborative planning

- Speed and coordination are inhibited by:
  - Stove-piped systems
  - Loose coupling of command centers
  - High training requirements
  - Under manning

Autonomous, proactive nature of agent paradigm improves speed and coordination
• Enabling Agent Features
  – Autonomous: require minimal supervision
  – Fast: Scan and correlate information rapidly
  – Vigilant: persistently monitor the environment
  – Reactive: Sensitive to Process Status
  – Communicative: Interact with the environment and the users
  – Intelligent: encapsulate decision support logic

Smaller staff handle higher operational tempo
Push, Pull, and Sentinel Agents

- Lessons learned in over 15 agent projects point to three core information functions:
  - Push - Information Dissemination
    - Assured “task & forget” information delivery
    - Intelligent selection of recipients
  - Pull - Information Discovery
    - “Power-assist” for users’ information search
    - Agents integrate information from disparate sources
  - Sentinels - Persistent Information Analysis
    - Collect data, interpret, alert

Agents reduce work and accelerate decisions
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Proactive Decision Support

- **Information Correlation**
  - Based on domain criteria, e.g. co-location
- **Threat Assessment**
  - Based on a threat taxonomy and fuzzy decision rules
- **Information Need Anticipation**
  - Based on task profiles
- **Also:** exploits non-agent functions, e.g., sensor and track fusion, non-cooperative target ID

Agents reduce work and accelerate decisions
Cherry Picking for Faster Identification of Time Critical Information

Time Critical Target (TCT) Attack Process

Intelligent Agents
Automatically and Persistently Monitor Multiple Sources for Relevant Information

Agents Deliver Found Information and Alert operator

Fires Process
SIPRNET Sources
Web Sources
Intel Sources
Imagery Sources

Faster Identification → Faster Prosecution
REAR HUMINT OPERATIONS PROCESS
Cascade Peak Exercise, Nov. 1996

1303 - HTOC receives, reviews, and forwards spot report from IPW team about a captured enemy order: "Directing 50% SPF ... attack Corps helicopter assets."

1400 - Forward and rear ACE and TOC/RAOC receive the report and prepare reaction.

1405 - Final Report

Commander receives and is able to act on critical information in minutes versus hours!
Vigilant Advisor for LogC2 / Agile Commander ATDs

Technology Demonstration of distributed mobile agent-based execution monitoring and counteraction recommendation.

CoABS GRID
- Tactical Communications
- Digital Backbone
- Core Jini Services

Vigilant Advisor Service
- Execution Monitoring
- Counteraction Recommendation
- Agent Service Coordinator

3rd Party Tools
- Knowledge Bases
- COAA Tools

Operational Information Sources

Planner/Commander Tools
- Interface to Vigilant Advisor Service
- Manage Profile Information
- Receive/review alerts and recommendations
- Supports intermittent connectivity

Mobile Agent System
- Focused extraction of information from operational sources
- Persistent Autonomous monitoring of current operations for contingencies
- Develop counteraction recommendations
- Unite best capabilities of multiple systems

Agile Software Components are a key enabling technology for Command Agility
Time-Critical Strike operations are frequently not fast enough to strike short dwell time targets with high confidence.

Shorten the “Decide” Phase

Increase Commander’s Confidence
CoABS Grid Interoperability Architecture

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CoABS Grid Interoperability Architecture

Java Platform: RMI, Jini
Purpose: to hasten the deployment of mature agent technology to C2 and combat systems.

Give domain experts the power to create, modify, and integrate agent applications.
The Semantic Web

- 1st generation web served information to humans, the 2nd generation web will accommodate software agents
- Tim Berners-Lee: “For the semantic web to function, computers must have access to structured collections of information and sets of inference rules that they can use to conduct automated reasoning."
  
  - http://www.w3.org/2001/sw/
  - http://www.daml.org
Semantic Web Roadmap

DAML (DAML+OIL) and DAML-Rules

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In the context of ‘asymmetric threats’, is John Smith affiliated with the Purple-Terrorists Organization?

Yes

Fact1: Crimson-Terrorists affiliated with Purple-Terrorists
Rule2: (?Person affilWith ?OrgA) (?OrgA affilWith ?OrgB) => (?Person affilWith ?OrgB)
Fact2: John Smith affiliated with Crimson-Terrorists