ABSTRACT

In this presentation we’ll provide a brief background on intelligent agent technology, motivate and describe the approach, design and initial implementation results obtained from prototyping intelligent agents as part of a suite of battle command services. These services are currently under development as part of the Tactical Information Technology for Assured Network Operations (TITAN) Army Technology Objective - Development (ATO-D) Program focused on Information Dissemination and Management (ID&M) for Battle Command (BC) Services. The Program was initiated by the Army in October 2008 leveraging the results of the Army Intelligent Agent Sub-IPT to span and integrate available resources associated with ID&M, Network Management (NM) Information Assurance (IA) technologies. This talk, however, will be limited to ID&M area. The objective of TITAN IM&D is to develop a set of core BC Support Services that will reside with the BC Common Services servers to be fielded as part of the Army Current Force BC systems in support of net-centric BC interoperability and collaboration. This core set consists of the following BC Support services: a) OPORD, b) Battle Book, c) Alert and Warning, d) Smart Filtering, e) Workflow Orchestration, f) Initialization and Continuity of Operations, g) Product Dissemination, h) Early Warning, i) MultiMedia, and j) BC Query. All of the above services are supported by a single BC Warfighter Machine Interface with tailorable plugins and a single Message Object Library, based upon a single C2 Product-oriented XML Schema. The primary approach of this effort is to leverage Intelligent Agent Technology and build upon the success of the previous related programs. TITAN software agents are responsible for the functionality and behavior of TITAN BC Services. In this presentation we will describe four types of computational behaviors associated with Commander’s Critical Information Requirements (CCIR) that were derived in response to general requirements associated with the Military Decision Making Process. They include area protection, route protection, hotspot recognition and route deviation.
Intelligent agents are:
• Software agents that exhibit a set of behaviors.
• Situated computational processes—instantiated programs existing within an environment that they sense and affect.
• Actively receive inputs from environment.
• Responses may manipulate and affect the environment.

Being situated in an environment is a key property of agents

Agent Properties

• **Autonomous.** Agents may perform their own decision-making, and need not necessarily comply with commands and requests from other entities.

• **Proactive.** Agents need not wait for commands or requests and may initiate actions of their own accord.

• **Interactive.** Agents may observably respond to external signals from the environment, e.g. reacting to sensed percepts or exchanging messages.
**Continuous.** Agents are typically a long-lived thread of execution.

**Social.** Agents interact significantly with other agents in achieving their tasks.

**Mobile.** Agents may migrate between computing devices—temporarily pausing execution, transferring to another host, and there continuing execution.

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**Agents** implement the application. Achieve the intended functionality of the system.

**Frameworks** provide functionality specific to agent software, acting as an interface or abstraction between the agents and the underlying layers. (ex. JADE, COUGAAR, etc.)

**Platforms** provide more generic infrastructure from which frameworks and agents are constructed and executed. (ex. Windows, Linux, etc.)

**Hosts** are the computing devices on which the infrastructure and agents execute. (ex. PC, PDA, etc.)

**Environment** is the world in which the infrastructure and agents exist.
Abstract Model of an Agent System

Agent-Based System

Agent Controller

Sensor Interface

Effector Interface

Agent Framework(s)

Platform(s)

Host(s)

Physical World

*Agent-Based Systems Reference Model

(See http://gicl.cs.drexel.edu/people/regli/reference_model-v1a.pdf)

JADE: Java Agent DEvelopment Framework

- FIPA-Compliant Multi-Agent Platform
  - Full Communication model - FIPA-ACL, ontologies, transport (RMI, IIOP, HTTP)
  - Support of Abstract Architecture
    - AMS (Agent Management System) – “white pages”
    - DF (Directory Facilitator) – “yellow pages”
    - ACC (Agent Communication Channel) – message routing
- GUI for remote management, monitoring, control
- Directory Facilities (DFs) can be federated allowing one GUI to control agents on other agent platforms (even non-JADE)
- Efficient Parallel Behavior One thread per agent
  - Multiple concurrent behaviors cooperatively scheduled
**How can we improve execution monitoring**

- When, where, why, and how should a subordinate Unit/Asset, executing its part of the plan, alert its partners and/or its HQ that it is not or cannot continue on time with the current Course of Action?

### Target X: 35°15’22”N 116°41’24”W
Types of Orders

• Administrative Orders
• Combat Orders
  – Warning Order (WARNO)
  – Operations Order (OPORD)
  – Fragmentary Order (FRAGO)
• **WARNO**
  - Preliminary Notice “Heads up”, Facilitates Time Management
  - Provides operational details
  - Outlines key events for mission execution (focus on mission preparation), Detail dependent on:
    - Information and time available
    - Information needed by subordinates for proper planning & preparation
• **OPORD**
  - Directive issued to subordinate commanders,
  - Information to effect execution of an operation
  - Always specifies execution time and date
  - Focus is on what to do, not how to do it
  - Explains why the mission is important
• **FRAGO**
  - Address only parts of the OPORD that change
  - A brief outline of the changes and instructions

### OPORD - A Basic Outline

- **Situation**
  - Enemy Forces
  - Friendly Forces
  - Attachments and Detachments

- **Mission**

- **Execution**
  - Concept of the Operation
    - **Maneuver**
    - **Fires**
      - Tasks to Maneuver Units
      - Tasks to Combat Support Units
      - Coordinating Instructions

- **Service Support**
  - General
  - Materiel and Services
    - Supply
    - Transportation
    - Maintenance
    - Medical Evacuations
  - Personnel

- **Command and Signal**
  - Command
  - Signal
Field Orders* A Unified Context for C2 Mission Products

**Technology Driven. Warfighter Focused.**
*See FM 5-0 e.q. p.202/FM 6-0

**Standard Objects For Orders**
(OPLANs, WARNOs, OPORDs, FRAGOs)

**Product**

- **Unit n: OPORD(n)**
  - Header(n)
  - 1. Situation(n)
    - a. Enemy(n)
    - b. Friendly(n)
    - c. Civilians(n)
    - d. Weather(n)
  - 2. Mission(n)
  - 3. Execution(n)
  - 4. ServiceSpt(n)
  - 5. C3 (n)
    - A. TaskOrg(n)
    - B. Intell(n)
    - C. OpsOverlay(n)
    - Z. Annex xyz(n)

**Book / Document**

- **Product**
  - **Topic**
    - **Fact**
      - Fact
      - Fact
    - Z. Annex xyz(n)

**Fact = \{Who(unit/asset), What(do), Whom(unit/asset), When(on), Where (at), Why (to), How(by), ...\}**

**Technology Driven. Warfighter Focused.**
Unit Hierarchy and Tactical Orders

Concurrent and Sequential Processes & Activities throughout a Mission Lifecycle

OPORD\(_0^{(n+1)}\)  OPORD\(_0^{(n)}\)  OPORD\(_1^{(n+1)}\)  OPORD\(_1^{(n)}\)  OPORD\(_2^{(n+1)}\)  OPORD\(_2^{(n)}\)

0 - Previous  1 - Current  2 - Next

FM 6-0
FM 6-0
Information Dissemination & Management (ID&M)

Vertical and Horizontal ID&M

Echelon n+1

Echelon n

Echelon n-1
COMBAT ORDERS FLOWCHART

ORDER ISSUED TO YOU
I. SITUATION
   A. Enemy Forces
   B. Friendly Forces
      1. Higher
         (a.) Mission
         (b.) Intent
      2. Adjacent
      3. Supporting
   C. Attach/Detach
II. MISSION
III. EXECUTION
   A. Cmdr's Intent
   B. Concept of the Op
      (a.) Scheme of Maneuver
      (b.) Fire Support Plan
   C. Tasks
   D. Coordinating Instructions
IV. ADMIN/LOGISTICS
V. COMMAND/SIGNAL

ORDER YOU ISSUE
I. SITUATION
   A. Enemy Forces
   B. Friendly Forces
      1. Higher
         (a.) Mission
         (b.) Intent
      2. Adjacent
      3. Supporting
   C. Attach/Detach
II. MISSION
III. EXECUTION
   A. Cmdr's Intent
   B. Concept of the Op
      (a.) Scheme of Maneuver
      (b.) Fire Support Plan
   C. Tasks
   D. Coordinating Instructions
IV. ADMIN/LOGISTICS
V. COMMAND/SIGNAL

Mangement and Dissemination of Plans and Orders

UNT(P) -> WPOF(P) -> opsOrd -> runEstimate -> wmpIn -> WARNO(O) -> opsOrd -> runEstimate -> wmpIn -> WARNO(O) -> opsOrd -> runEstimate

UNT(O) -> opsOrd -> runEstimate -> OPORD(O) -> opsOrd -> runEstimate -> FRG(O) -> opsOrd -> runEstimate

UNT(D) -> opsOrd -> runEstimate

UNTO(0) -> opsOrd -> runEstimate 

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
Notes on Management and Dissemination of Plans and Orders

- **UNT** – Unit system
- **P** – Parent
- **D** – Dissemination / Distribution (parent, subordinates, adjacent, supported units)
- **O** – Own
- **WRN** – WARNING prdC2 subsystem
- **PLN** – OPLAN prdC2 subsystem
- **OPS** – OPORD prdC2 subsystem
- **FRG** – FRAGO prdC2 subsystem
- **WPOF** – WARNO | OPLAN | OPORD | FRAGO
- **WARNO** – Warning Order
- **OPLAN** – Operations Plan
- **OPORD** – Operations Order
- **FRAGO** – Fragmentary Order
- **runEstimate** is based upon current opsOrd
- **opsOrd** – imports current OPORD updated with current COP and all FRAGOs issued since OPORD was issued.
- **wrnPln** – Planned WARNO
- **opsPln** – Planned OPORD including assumption and relative times (H-Hour / D-Day)
- **frgPln** – Planned FRAGO

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**State Model of C2 Products**

\[ p_{rdPln}(n) \]
\[ \text{wrnPln}, \text{opsPln}, \text{frgPln} \]
\[ p_{rdOrd}(n) \]
\[ \text{wrnOrd}, \text{opsOrd}, \text{frgOrd} \]

\( n \) - echelon
\mbox{prd} - product
\mbox{pln} - plan
\mbox{wrn} - warning
\mbox{frg} - fragment

\begin{align*}
\text{initialize} & \quad \text{collaborate} & \quad \text{execute} \\
\text{plan}\,(n) & \quad \text{rpt} & \quad \text{rpt} \\
\text{prdPln} & \quad \text{wrnPln} & \quad \text{wrnOrd} \\
\text{opsPln} & \quad \text{opsPln} & \quad \text{opsOrd} \\
\text{frgPln} & \quad \text{frgPln} & \quad \text{frgOrd} \\
\end{align*}

**prdIM**: prdPln, prdOrd
**prdID**: WARNO, OPLAN, OPORD, FRAGO
**IM**: Information Management
**ID**: Information Dissemination

**Dissemination by PDS**
Notes on State Model

- Publishing and disseminating prdID
  - WARNO(n) – wrnOrd (execute, fnl,n) updated by running estimates as required
  - OPLAN(n) – opsPln (collaborate,fnl,n) updated by running estimates as required
  - OPORD(n) – opsOrd (execute, fnl,n) updated by running estimates as required
  - FRAGO(n) – frgOrd (execute, fnl,n) updated by running estimates as required

- Transitioning and publishing prdIM
  - WARNO(n+1) → wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln (initialize, *, n)
  - OPLAN(n+1) → wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln (initialize, *, n)
  - OPORD(n+1) → wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln ( initialize, *, n)
  - FRAGO(n+1) → wrnPln (initialize, *, n), opsPln (initialize, *, n), frgPln (initialize, *, n)

- * prdC2:status:init will be used if this is the first time that any prdID(n+1) has been received,
- prdC2:status:updt will be used if prdC2:status:init has been previously published,
- prdC2:status:fnl will be used if prdC2:status:init/updt has been previously published
- wrnPln (initialize, fnl, n) → wrnPln (collaborate, init, n)
- opsPln (initialize, fnl, n) → opsPln (collaborate, init, n)
- frgPln (initialize, fnl, n) → frgPln (collaborate, init, n)
- wrnPln (collaborate, fnl, n) → wrnOrd (execute, init, n)
- opsPln (collaborate, fnl, n) → opsOrd (execute, init, n)
- frgPln (collaborate, fnl, n) → frgOrd (execute, init, n)
- wrnOrd (execute, *, n) → WARNO(n)
- opsOrd (execute, *, n) → OPORD(n)
- frgOrd (execute, *, n) → FRAGO(n)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Battle Command Support Services Concept

MultiMedia Support (MMS) Service
Battle Book Support (BBS) Service
Smart Filtering Support (SFS) Service

OPORD Support (OPS) Service
Early Warning Support (EWS) Service
Alert & Warning Support (AWS) Service
Workflow Orchestration Support (WOS) Service
Product Dissemination Support (PDS) Service
BC Query Support (BQS) Service

Initialization & COOPS Support (ICS) Service

TITAN Services will be SOAF-A compliant and utilize BCCS Infrastructure

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.
An Integrated Architecture

TITAN BC Support Services & Agents

TITAN JMS

BCW

TITAN BQS

VMF*

TITAN JDS

NFFI*

TITAN BC Support Services & Agents

ABCS

MIP

* proposed

TITAN ATO-JC3IEDM Interface Architecture

JMS Topics

Init/Update

Fdbk

Data Updates

Pos/Spot Reports

Init

Data Updates

BQS Control MDB

BQS JC3IEDM MDB

BQS Execute MDB

JC3IEDM Notif. Recpt. W/S

BQS / BCW or any TBS

C2D

BCBL

JC3IEDM Data Service

JC3IEDM Notification Service

JC3IEDM Database

TITANasess

TITANcontrol

TITANplan

TITANexecute

TITANjc3iedm

TITAN ATO-JC3IEDM Interface Architecture

JMS Topics

Init/Update

Fdbk

Data Updates

Pos/Spot Reports

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BQS / BCW or any TBS

C2D

BCBL

JC3IEDM Data Service

JC3IEDM Notification Service

JC3IEDM Database

TITANasess

TITANcontrol

TITANplan

TITANexecute

TITANjc3iedm

* proposed
OPS Services and Agents

• OPORD Support (OPS) Service
  – Provides BFAs with access to an authoritative source of a distributed, updateable linkable, highly structured XML managed plans and orders organized by units available for collaboration or dissemination.
  – Includes relevant Mission Products such as COP, Missions, Commanders intent, COO / COA / Tasks, Coordinating Instructions (CCIRs), Task Organization, Overlays, and other available Annexes.
    • Managed Plan/order update Agent
    • Aggregated Disposition Agent
    • AoR / CM Agent
    • Activity Tracking Agent
• Battle Book Support (BBS) Service
  – Provides Commanders and Staff with access to data base of Order of Battle (based on TO&E, MTO&E, Consumables for Friendly, Neutral, and Enemy). Asset Capabilities including weapons, sensors, communications and mobility
  – Provides Decision Support Tools (Services and Intelligent Agents) with computational parameters needed for CCIR / COA analyses
    • Capability update Agent
    • Capability Aggregation Agent
    • TOE Agent

• Alert&Warning Support (AWS) Service
  – Supports the generation of warnings and alerts relevant to CCIRs and other coordinating instructions to include Space and Missile Defense sources
  – Provides predictive assessments and indications of imminent and evolving situations
  – Support CCIR-driven re-planning and Execution
    • Area Protection Agent
    • Route Protection Agent
    • Route Deviation Agent
    • Space-Time Event Cluster Agent
    • Readiness Agent
    • Strength Agent
• Smart Filtering Support (SFS) Service
   – Enables the extraction of structured data (graphics, numeric, tabular) from free text reports and messages
   – Identifies reports with relevant content for further analyses
     • Significant Fact Agent

• Workflow Orchestration Support (WOS) Service
   – Provide a SoA Foundation - Army Point of Presence gateway to and from associated TITAN BC services from and to external SoA clients
   – Synchronize requests and responses by organizing the workflow of Services across the enterprise by recommending the sequencing coordination activities, tasks and events
     • Access Policy Agent
     • Service Notification Agent
     • Client Posting Agent
• **Product Dissemination Support (PDS) Service**
  
  - *Use OPORD Task Organization and Friendly Situation to determine the addressees to be entered for Dissemination of OPORDs and associated Reports*
  
  - *Use NETOPS C2 Registry to determine IP addresses for communications over the Tactical Internet invoking QoS, CoS and appropriate policies*
    
    • QOS Agent
    • COS Agent
    • Contact Management Agent

• **Initialization & COOPS Support (ICS) Service**
  
  - *Use Parent unit WARNO / OPORD to initialize Own unit OPLAN*
  
  - *Use Task organization to Support collaboration with Session, Presentation and Application levels of Data Initialization*
  
  - *Ensure that common relevant data is available to each mission and task work group*
    
    • Order Initialization Agent
    • Service Connectivity Agent (Using DDS, C2R)
    • Service Federation Agent
• svcToolBar - select and access TBSsvc

• prdC2menu - select prdC2:Type, pull down latest available instances, select instances)

• svcNavPanel – expandable outline, directory-like structure, selectable leaf objects (e.g. unit:, env:, crd:, txt:) highlighted in svcVisPanel and BCWdisPanel

• svcCntrlPanel – set conditions, constraints, & options for behaviors to assess & monitor

• svcStatusPanel – KNW / UNK info, activities indicator, IWA and recommendations

Notes on Plug-in Capabilities

• Svc – Service such as OPSsvc, AWSsvc, BBSsvc, SFSsvc, ICSsvc, WOSsvc, PDSsvc

• TBS – TITAN Battle Command Support

• prdC2 – a managed C2 Product for dissemination

• Nav – Navigation

• Env: – Environment Object element

• Crd: – Coordination Object element

• Vis – Visualization

• Cntrl – Control

• Dis – Display

• KNW – Known

• UNK – Unknown

• IWA – Indications, Warnings and Alerts
Plug-in Objective Capabilities: A standard set of APIs

**svcToolBar** - Select TBSsvc, Access TBSsvc

**svcNavPanel** –
- expandable outline,
- directory-like structure
- selectable leaf objects
  - unit:
  - crd:
  - env:
  - btx:
- Highlighted
- in svcVisPanel and BCWdisPanel

**prdC2menu**
- select prdC2:Type:
- pull down latest available instances
- select instances

**svcCntrPanel** –
- set conditions,
- constraints, & options
- for behaviors
- to assess & monitor

**svcStatusPanel** –
- KNW info
- UNK info
- Activities indicators
- Progress statistics
  - IWAs
  - &
  - Conclusions
- Recommendations

- **svcVisPanel** is controlled by svcNavPanel,
- **svcVisPanel** is uses the BCWdisPanel.
- **BCWdisPanel** is controlled by BCWnavPanel

![Image of Web Command & Control Portal](image-url)
• NAI, TAI for Decision Points based upon Event Hotspot

• Threat Indications Warnings and Alerts based upon Enemy Location and Capability

AWS Service