2006

Event Processing in the Global Information Grid GIG): Orders of Magnitude Advantage in Information Supply Chains through Context-sensitive Smart Push VIRT

Event Processing in the Global Information Grid (GIG):

Orders of Magnitude Advantage in Information Supply Chains through Context-sensitive Smart Push ("VIRT")

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November, 2006

The What and How of DoD's Information Superiority

- ***What is information superiority?***
  - ***A state where each operator acquires all relevant information in a timely way***
- ***How is information superiority achieved?***
  - **A Global Information Grid (GIG) enables each operator to access quickly all relevant information**
    - **Produces shared awareness, better decisions, and greater agility.**

***Fallacy*:**

plentiful information & unlimited bandwidth will make it so

Model-based Communication Networks:
Seeking a "mind meld" (shared situation models) under resource constraints

- **Challenges**
  - Distributed entities have different concerns and perspectives
  - Dynamic situations evolve rapidly
  - Data updates glut channels and processors
  - Backlogs build and processing entities thrash
- **MCN remedy: optimize information flows**
  - Each node lets others know its concerns
  - Every node maintains dynamic models
    - Of itself
    - Of others
  - A node X informs a node Y when X detects an event that affects Y

MCNs: *State-full* Networking

Model-based Communication Networks,

unlike current *stateless* networks,

remember what's been communicated,

maintain a distributed understanding of state,

& exploit state to avoid sending low-value bits

The Basic Ideas

1. Optimize info chains (bit flows) for each operator
   - Get the high-value bits to operators quickly (VIRT)
   - Reduce the number of low-value bits they receive
2. Measure the productivity of information processes
   - Compare “smart pull” to “smart push”
   - Show 5 orders of magnitude advantage for “smart push”
3. Shift efforts in DoD to VIRT and Smart Push
   - Value derives from operator plans and contexts
   - Filters use COIs to optimize flow: significant “news”
   - This filtering dictates priorities for semantic mark-ups
4. Implement information superiority incrementally
   - One operator “thread” at-a-time
   - Delivering a few, high-value bits, swiftly
   - Continually improving COIs & enabling semantics

VIRT = Valuable Information at the Right Time
COI = Condition Of Interest

Two Basic Approaches: Pull v. Push

- **Theory 1 – Smart Pull**
  - Describe all information available using some type of meta-data description.
  - Give each processing entity good search tools.
  - Each entity seeks and acquires whatever information it needs, when and as needed.
- **Theory 2 – Smart Push**
  - Each processing entity describes conditions that would make its current plans undesirable, *i.e.* which contradict assumptions justifying the plan.
  - Agents alert the affected entity.
  - The entity responds quickly to the received news.

Condition Monitoring is Key

- Conditions of Interest (COIs)
  - Computable expressions ("continuous queries")
  - Describe critical assumptions (like CCIRs)
  - Depend on operator's evolving context
    - Usually reflect phase of a mission & current status
- High-value events are detected
  - Data describing the event match the COI
  - The event is "news"
  - The COI assures the event is still "relevant"
  - Bits reporting the event flow with priority
- Low-value data do not flow
  - Generally "relevant" data not matching a COI
  - Repeated and redundant data, not newsworthy

Numerical Analysis of Example

- Theater & Information Sources
  - Area of interest is 200 km X 200 km
  - Lat-long mesh 1 km x 1 km => 40K grid points
  - Altitude ranges to 6km, 500m mesh => 13 planes
  - Time span = 4.5hr, gridded @ 30min => 10 slices
  - 10 variables of interest

    → 50M apparently relevant data values
  - Data refreshed on average every 30 min
- Pilot's strategy: Reexamination every 10 min
  - 27 reexaminations over the 4.5 hr mission
- Conservative assumptions
  - 90% automatically dropped as "obviously" not "relevant"
  - 90% automatically dropped as "obviously" not "significant"

    → Theory 1 gets just 1% of apparently relevant data

Comparing Process Efficiencies

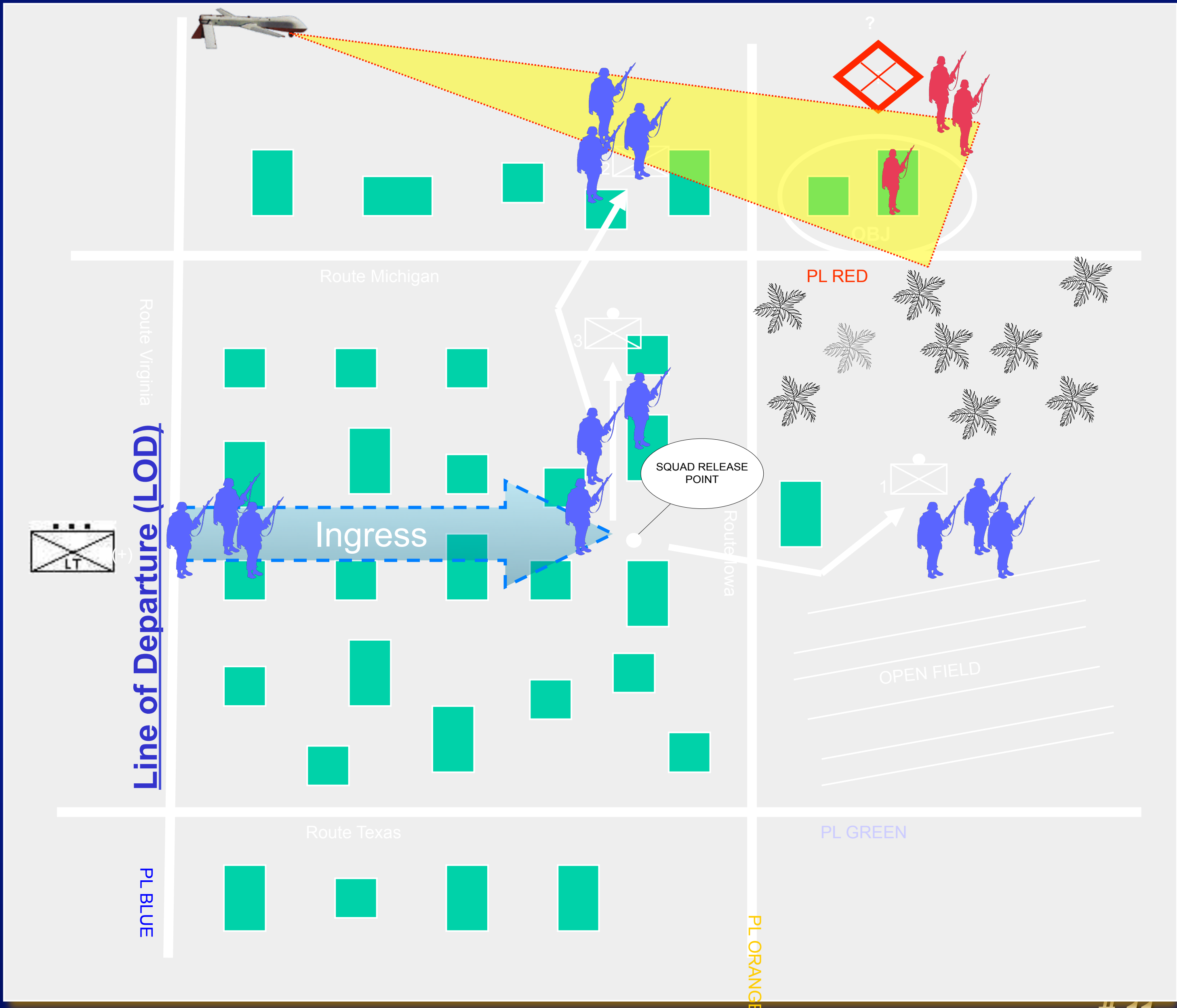
- **Theory 1 (Smart Pull)**
  - Every 10 minutes, 1% of 50M data values received
  - I.e., 500K relevant & significant data values
  - Equivalently, 50K items per minute, or 800/sec
  - As a consequence, the pilot "skims" the glut
- **Theory 2 (Smart Push)**
  - Every 10 minutes, 0 or a small number of significant events will occur
  - As a consequence, the pilot has required cognitive resources to process any event
- **Theory 2 : Theory 1 (Push >> Pull)**
  - 99.999% less data for the operator to consider
  - 5 orders of magnitude more efficient

Can DoD Implement VIRT?

- Incremental, evolutionary process critical
  - Necessary: won't achieve information superiority all at once
  - Sufficient: each operator mission addressed adds to superiority
- Incremental, evolutionary process is Pareto optimal
  - Focused by value for actual missions, implementation delivers maximum "bang for the buck"
  - By focusing on individual missions, one-at-a-time, we minimize implementation failures, delays, budget over-runs
  - No other approach can maximize expected returns on investment
- Specific work required
  - Select specific operator missions
  - Determine their mission success requirements
  - Negate their success requirements to define COIs
  - Implement COI monitoring
    - Many important, reusable components result
    - Adapt doctrine, tactics, training to exploit dynamic, informed operators
  - Implement continuous improvement process

USMC-VIRT Scenario: High Value Target Raid

- Platoon Sized Force
- Each squad deploys to their positions



LEGEND

- One Story Bldg
- Two Story Bldg
- Palm Grove

Conditions of Interest

1-1. Notify me if my target location is no longer valid.
1-1.a. The distance we are concerned with is a variable. For this instance, we say +/- 100m

1-2-1. Tell me if there are any of friendly organic forces injured to the extent that it impacts mission accomplishment.
1-2-1.a. Variable here is the definition of what hinders the mission. Examples include mobility, life threatening injuries, and combat effectiveness issues.

1-2-2. Same as 1-1. Variable here is the distance of the squad from it's expected location; We are concerned with +/- 50m.

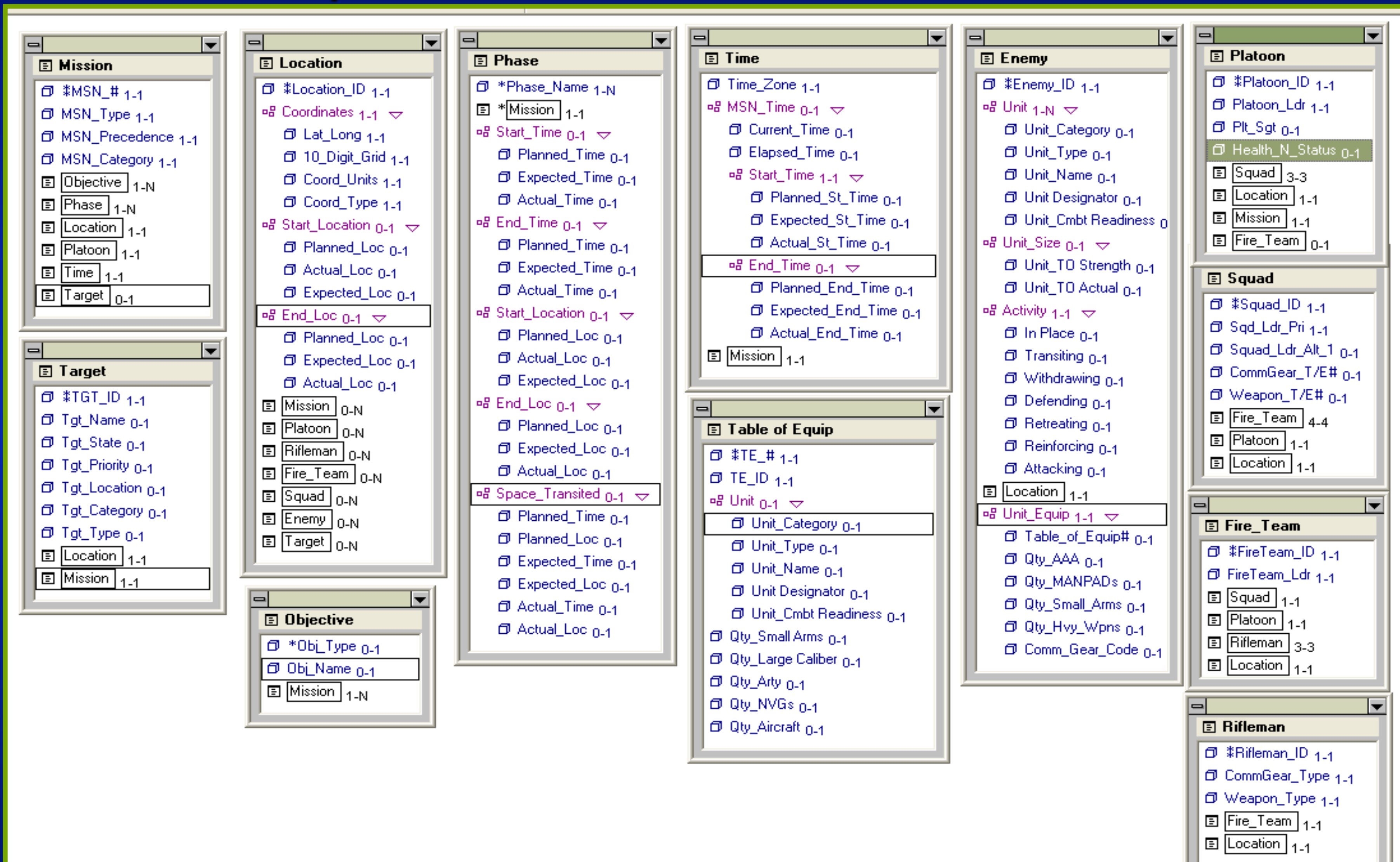
1-2-3. Tell me if any organic blue force weapons become inoperable.
1-2-3a. By inoperable, we mean incapable of sending a round downrange. Does not take into account multiple weapon systems (203 grenade launcher).

1-3. Notify me if I’m about to lose comms.

Plan Assumptions	Negated Assumptions
Target location known	Actual target location not as planned / expected
All organic blue forces are mission capable	Organic blue force casualties exceed Go-No-Go threshold
Squads’ locations are accurate	Squads' locations are not as planned / expected
Weapons are mission capable	# non-mission-capable weapon systems exceeds Go / No-Go threshold
Still within my communication's threshold	Approaching my communication device's threshold

USMC-VIRT Semantic Object Model v.1

Concepts of…



Example Information Requirements and Conditions of Interest (COIs)

In_1.0		//Target Location has changed//
	1	Current target location not as planned

[Mission]:Msn_#, Msn_Type-HVT[Phase]:= Ingress, [Target]:Tgt_ID, [Location]: Location_ID, Coordinates ≠ Coordinates Planned

	2	Current target location not as expected

[Mission]:Msn_#, Msn_Type-HVT[Phase]:= Ingress, [Target]:Tgt_ID, [Location]: Location_ID, Coordinates ≠ Coordinates Expected

In_2.0		//Health & status of organic, mission assigned, friendly forces//
	1	Blue organic force member is seriously injured

[Mission]:Msn_#, Msn_Type-HVT[Phase]:= Ingress, [Rifleman]: Rifleman_ID **and/or** [Squad]: Sqd_Ldr **and /or** [Fire_Team]: FireTeam_Ldr, Health_N_Status **=** Serious Injury

	2	# of organic blue forces injured exceeds mission Go-No-Go criteria

[Mission]:Msn_#, Msn_Type-HVT[Phase]:= Ingress, [Rifleman]: Rifleman_ID **and/or** [Squad]: Sqd_Ldr **and /or** [Fire_Team]: FireTeam_Ldr, Health_N_Status **SUM Qty** Serious Injury **≥ Go_No_Go_Criteria {abort}**

In_3.0		//Location of msn essential organic blue force maneuver elements, in this case a 12 man squad.//
	1	Current position of Squad(n) is not as planned

[Mission]:Msn_#, Msn_Type-HVT[Phase]:= Ingress, [Squad]:Squad_ID, [Location]: Location_ID, Coordinates ≠ Coordinates Planned

Key Technology Shortcomings

1. Models of mission types with goals, activity models, assumed and predicted states, assumptions, and justifications.
2. Tailorable process for monitoring COIs and alerting operators.
3. Vocabularies that operators find natural and useful in characterizing their COIs.
4. An expression language operators can write and read to define COIs that uses their own vocabulary simply.
5. "Cartridges" or "blades" for the most popular database products that make it easy to define models suitable for typical vocabularies, expressions, and COIs.
6. Standard solutions for expressions involving space-time intersections. Make it easy to "mix in" space and time dimensions to virtually any ontology.
7. Tools to audit information flows and to determine specifically "why" particular alerts occurred or "why not" when they didn't.
8. Tools to improve the information value chains by fixing bugs in the vocabularies, expressions or COIs.

High-Value Event Types

a) Does an entity's route intersect another's range of capability (e.g., detection, weapons) at some time t?
b) Where is an entity expected to be and what area is included in its range of capability at some future time t?
c) What other positions and areas are possible, even if not currently expected?
d) Will one entity detect another? With what probability?
e) How long will an entity's plan (e.g., planned route to destination) take?
f) Will the entity exhaust any of its resources (e.g., fuel) before completing?
g) Does the probability exceed a threshold (e.g., 5%), that the ranges of capabilities (e.g., detection, weapons) of two entities will intersect (over the time remaining)?
h) What's the probability that two entities will interact (e.g., collide, detect one another)?
i) If two entities need to interact continually (e.g., remain in communication), will they?

Conclusion

- Theory of NCOW / Information Superiority:
  "quickly get information to those who will benefit"
- Two very different process designs
  - DoD's approach: Mark it all up with semantic meta-data
    so operators can pull what they deem relevant
  - Smart Push: Analyze how info improves mission outcomes
    so machines can watch for that information
    and push it to operators
- The two designs address different types of problems
- VIRT offers *orders of magnitude* greater bang for the buck
- Information value-delivery chains provide the organizing principle for a revolution in IT-leveraged mission effectiveness