12th ICCRTS
"Adapting C2 to the 21st Century"

Situation Awareness and Dynamic Group Formation of Agents and Humans Using Jabber

Group specification via focused doxastic summary functions

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Problem - Solution

Enemy tactics evolve to erode existing methodologies, evade detection, and mute efforts against them.

Dynamic RTOC groups of humans and agents better adapt to fluid situations and exploit opportunities

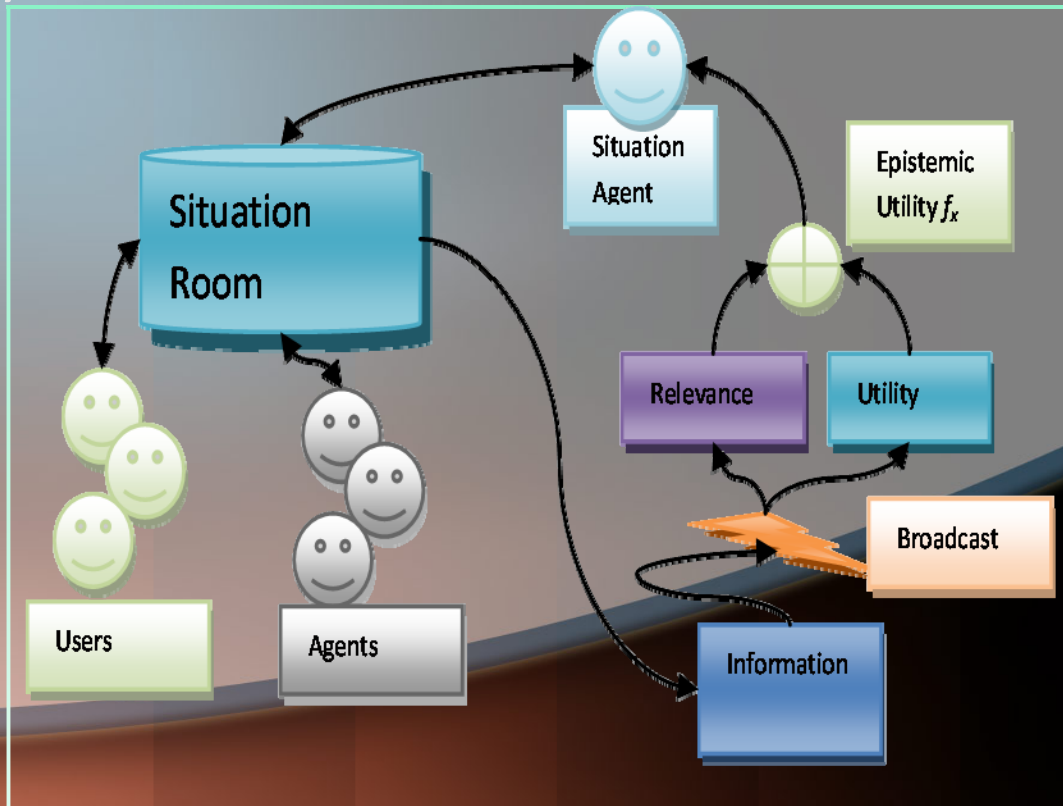
Dynamic Groups and Knowledge

- Real-time online communication (RTOC) is being use more frequently, and warfighters are increasingly familiar and proficient with chat and texting.
- RTOC users are efficient at communicating salient points, building consensus and folksonomic knowledge.
- Formal knowledge methods require preparation and are unlikely to work by analogy, as RTOC users can.

Jabber

Overview

- Mixture of canonical and de facto knowledge representation using standard NCES RTOC capability to form dynamic groups of humans and agents.
  - Long history of "chat agents" that often included Google-like and other search capability based on context.
- Agents encapsulate semantic routing b/w other groups
- Semantic goal driven behavior requires relevance & utility



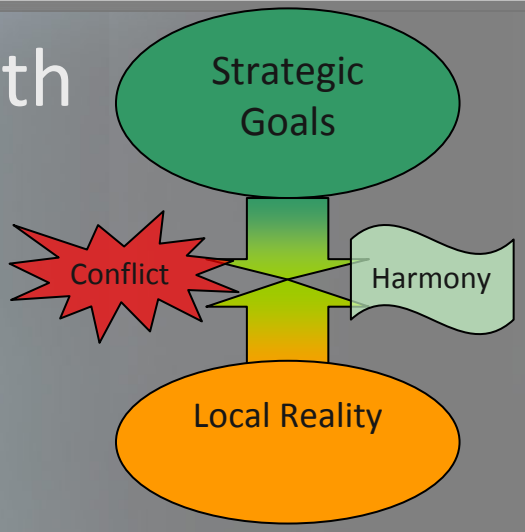
Notional IO Scenario

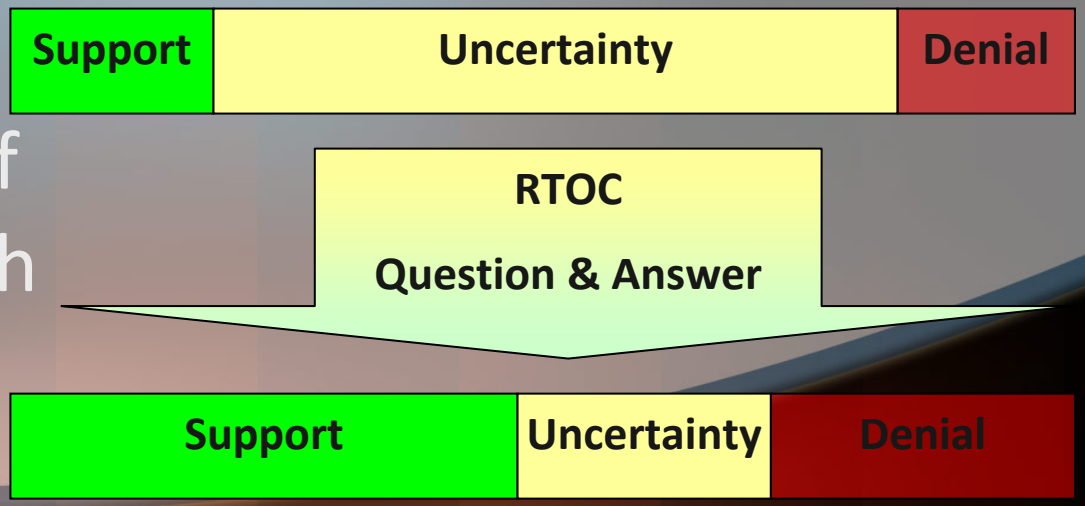
- Mission: exploit key enemy network equipment

```
Golden Spike Agent> 'Hammer' is within 10 meters of the 'target'.
Golden Spike Leader> can you see the equipment?
Hammer> y chinese?
Hammer> csco7606
Golden Spike Agent> 'target equipment' may be 'Cisco 7606'
Golden Spike Leader> use your termjack
Hammer> i505-D35
Golden Spike Agent> termjack classification requires secure access.
Golden Spike Agent> 'Golden Spike Leader' has granted access.
Golden Spike Agent> 'i505-D35' indicates target equipment is 'Cisco
7505' with 'IOS 12.1(5)XM4'
Golden Spike Leader> @send root kit
Golden Spike Agent> Sending 'Cisco 7505, 12.1 access kit' to
'Hammer'.
Hammer> k rdy njct
Golden Spike Leader> initiating sentinel
Hammer> k njct grn
Golden Spike Agent> ICMP packet traffic confirmed.
Golden Spike Leader> clear the target
Hammer> k
```

RTOC Question & Answer Process

- KR and NLP often have difficulty with problems of negation/dissonance
- Local reality is dissonant in new ways
  - forces learning , at any time may simultaneously support & deny goals.
- Doxastic Agent MoE is reduction of uncertainty through Q&A belief model

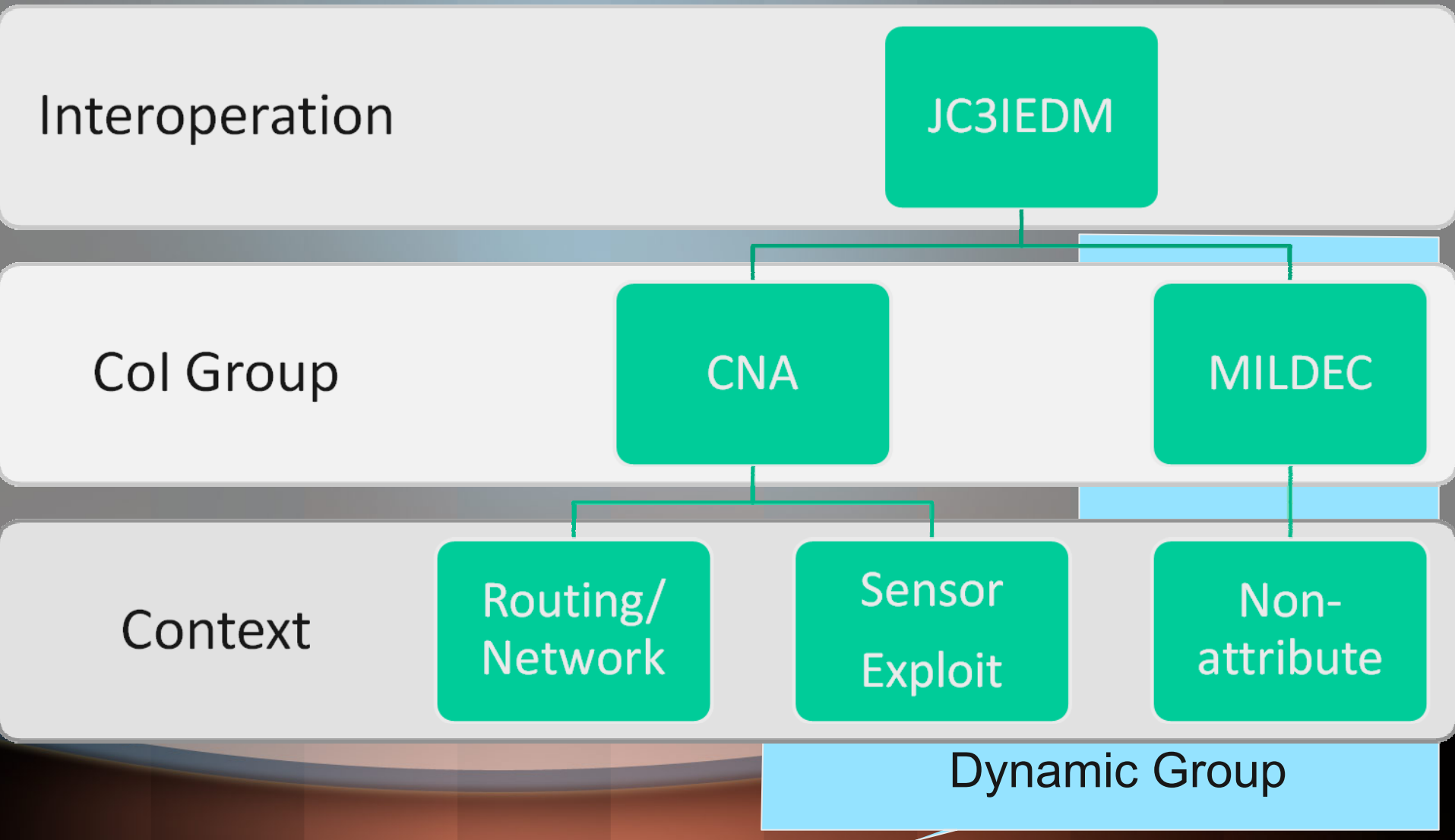




Aleatory and Epistemic Uncertainty

- Aleatory Uncertainty
  - Model of variability in the measure
    - Such as temperature, or other sensor data
- Epistemic Uncertainty
  - Model of uncertainty due to lack of knowledge
    - Unknown structure, correlation, and causal relationships
- Aleatory uncertainty is not reducible through reasoning strategies.
  - Knowledge structures that don’t account for gradations and reducibility of uncertainty, may create uncertainty.

Formal and Informal KR



Canonical Knowledge

- JC3IEDM schema tags good candidate for ontology interoperations
  - Slow to react & expensive to change
- Ex: JC3IEDM network-architecture-code

Value	Definition	Source	Physical Value	Identifier
ARCnet	The IEEE 802.4 network architecture.	MIP	ARCNET	1000001
Ethernet	The IEEE 802.3 (and derivatives) network architecture.	MIP	ETHRNT	1000002
Mixed	A network where more than one architecture is used.	NDAG	MIXED	1000003
Token ring	The IEEE 802.5 network architecture.	MIP	TKNRNG	1000004
Wireless	The IEEE 802.11 network architecture.	MIP	WRLESS	1000005
Not otherwise specified	The appropriate value is not in the set of specified values.	ATCCIS	NOS	1000006

Hedges and Uncertainty in Language

- Humans communicate uncertain information using hedges.
  - Easy and natural to use hedges and analogies to expedite communications
  - Computers have a difficult time interpreting and using this information.
  - Hedges and communicating uncertain information is a typical problem in NLP.

Percent	Tolerance	Hedge
100%	0%	Certainty
93%	6%	Almost Certain
75%	12%	Probable
50%	10%	Chances About Even
30%	10%	Probably Not
7%	5%	Almost Certainly Not
0%	0%	Impossibility

Overview Belief Algebra

- Subjective Logic
  - Mechanism for reasoning about beliefs or opinions
  - Algebra combining opinions made by differing authorities
  - Works well for *evidential reasoning*, where an opinion is formed based upon the amount of evidence in support of (belief), or against (disbelief), a given hypothesis.
- Opinion
  - Consists of belief (b), disbelief (d), uncertainty (u), and atomicity (a)
    - (b+d+u = 1.0)
  - Atomicity is a measure of proportionality, or *base rate*
- Example
  - ω = (0.3, 0.6, 0.1, 0.5)

$$w_x^A = (b_x^A, d_x^A, u_x^A, a_x^A)$$

Group/Agent Relative Belief

- Agent discounting
  - Canonical discounting via ranking based on semantic relevance, a priori, aging, or security
  - Learned discounting via belief updating, correlations, information aging, or integrity
- Relativized fact tuples allows agents to maintain working sets that aren't completely normalized or require the same ontology
- Agents can be queried in a belief space and discounted according to distance operators

$$\omega_{\theta}^{\alpha} \otimes \omega_{p}^{\theta} = \omega_{p}^{\alpha:\theta}$$

$$(\varphi, \omega_{\theta}^{\alpha}, \omega_{\varphi}^{\theta})$$

$$\omega_{p}^{\alpha} \oplus (\omega_{\beta}^{\alpha} \otimes \omega_{p}^{\beta}) = \omega_{p}^{\alpha} \oplus \omega_{p}^{\alpha:\beta} = \omega_{p}^{\alpha \circ (\alpha:\beta)}$$

Deriving Risk

- Risk valuation takes our cost of the outcome *y* and multiplies it by expectation (in this case, derived from an agents belief):

$$Risk(y, \omega_y) = C(y) \cdot E(\omega_y)$$

- The decomposition of the outcome, such as loss of life and property, is a task for epistemic reasoner and effects-based knowledge representation.
  - Example of sensible conjunction of threat (*t*) and vulnerability (*v*) causing risk to an asset (*a*)

$$(a \leftarrow t \wedge v, \omega_{a|t \wedge v})$$

Supporting Net-centric Warfare

- DoD Directive 8320.1 requires that information is:
  1. Available to the decision maker, when needed.
  2. Discoverable, with appropriate tagging.
  3. Sharable in public spaces, when possible.
  4. Broadcast-able, which enables “many-to-many” exchanges.
- Situation Groups
- Tagging and Discovery
- Information Sharing Spaces
- Many-to-Many Communications

Conclusions

- Real-time online communications is becoming an integral part of the warfighters toolset. Real-time online communications can assist the warfighter by facilitating situation refinement, but needs a mechanism for integrating mechanized reasoning in semi-structured format.

Questions?

Thank you!

- Questions?
- Technologies covered:
  - Jabber, XML Chat, Tactical Chat, Machine Learning, Natural Language Processing, Belief Algebra
- Contact:
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