DCODE

Decision Making Constructs in a Distributed Environment

Robert Fleming
SPAWAR Systems Center
bob.fleming@navy.mil
619.553.3628
Decision Making Constructs in a Distributed Environment

Space and Naval Warfare Systems Center, 53560 Hull St, San Diego, CA, 92152-5001

Approved for public release; distribution unlimited

Collaboration and Knowledge Management (CKM) Workshop, 13-15 Jan 2004, San Diego, CA
Overall Objectives

• Improve the quality of group decision making by
  – (1) enhancing the ability of each participant to assess/evaluate their pool of disparate information findings
  – (2) simplifying the process by which participants share uniquely held information
  – (3) improving the process for integrating this shared information into the on-going decision process and
  – (4) developing information “drill down” capabilities so that participants can quickly focus on the differing subjective assessments that are causing lack of decision consensus.
This year’s Objectives

• Expand development of IOBs
• Interface with EWALL project
Contribution to CKM

What are the task parameters?
- individual mental model construction
- knowledge interoperability development

What is the data saying?
- iterative information collection and analysis
- team shared understanding development
- develop, rationalize, & visualize solution alternatives

What is the group decision?
- team negotiation of solution alternatives
- team pattern recognition
- team shared understanding development
- convergence of individual mental models
- sharing hidden knowledge
Sample Decision Making Task

- We have spent a lot of money over the last two years on improving airport security.

- **Has Airport Security significantly improved?**
  - Review reports and assign an overall effect/impact score to the results:
    - NO!
    - Definitely has improved
    - Definitely Not improved
    - YES!
You search and retain 10 reports

Vulnerabilities an Improvements for FI

What GAO Found

Numerous government and non-government organizations have sought to improve airport security. These include

- US airline security has suffered in recent years.
- At least four separate terrorist threats involving hijacked planes have been reported in the US.
- But security experts say the threats have been relatively minor compared to the threat.
- Security on US domestic flights is so relaxed that

Guest Comment

Security, Smith's Way

The cyber model.

By James D. Miller, assistant professor of economics, Smith College

We ask the marketplace to strengthen airport security. The assumption is that airlines and airports will develop new security programs and technologies that are competitive. Only by making the security program competitive can we protect America's skies.

Computer networks have to reduce the risk of cyber-attacks. The government's emphasis on terrorism has forced the airlines to develop new technologies. But there is a need for a better way to protect against cyber-attacks. Computer security is not provided by the government, but rather by the marketplace that provides a way for security that can't protect against electronic attacks. Airports should be protected by a similar free market approach.

SPECIAL REPORT

The Sterile Airport

Airport security for the 21st century

By Dan Volos

We asked Lott Inc., a Denver-based security system designer, to help us engineer an airport that could target terrorists without blocking passenger traffic. The site included a computer security system, and other measures to protect the airport from computer records and other forms of disruption.

We got a target date of five years from now, but much of the technology is available, so we will proceed. The system is designed to be flexible and can be adapted to meet security needs by tagging, tracking, and instantly locating.

End of ED and Secure ED

Initial safeguards are in place outside the airport. Scanners at checkpoints like those used at airports, and more and more at airports.
Subjective conclusions from each of the reports

Yes!  No!  Yes!  No!  Yes!

Yes!  No!  Yes!  No!  Yes!
...but other subjective estimates have also been made.

**Difficult Task!**

- **Highly Reliable Source**: Yes! NO!
- **Old Data**: Yes! NO!
- **Good documentation**: Yes!
- **Least Important Source Creditability?**
- **High level of uncertainty**: No!
- **Most Important**: NO!
- **Very recent info.**: NO!
- **Old Data**
DCODE Solution: Convert **IMPLICIT** subjective estimates into **EXPLICIT** estimates.

Encapsulate the scores into an icon (called an Information Object, IOB) that displays information quality, impact and importance.

**Effect/Impact: Color**

**Quality of information**

**Information Importance:** Size of color bar (1, 2 or 3 sections filled)
Another look at the 10 reports

Drop all items with below average Source Credibility.
The decision environment:

Documents vs IOBs
DCODE IOB Process
What are the key Essential Elements that need to be Abstracted from an Information Item?

• Where does it **Fit?**
  – i.e. which decision criteria/factor (e.g. cost, risk, etc.)?

• How good is the information **Quality?**
  – What is the Credibility of the source?
  – How Timely is this information?
  – How much Confidence do I have in the information?

• What is the **Effect/Impact** of the information on the criterion?
  – **Positive or Negative?**
  – **Strong or Weak?**

• What is the **Importance** of this item relative to other items?
We access these subjective assessments via an **Abstraction Template** Structure

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Criteria</th>
<th>Fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Quality</td>
<td>Assessment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect/impact</th>
<th>Relative Importance</th>
</tr>
</thead>
</table>

Title: Aug 02 contract

<table>
<thead>
<tr>
<th>Criterion:</th>
<th>V.Low/Poor</th>
<th>Avg.</th>
<th>V.High/Good</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credibility:</td>
<td><img src="image" alt="Credibility" /></td>
<td><img src="image" alt="Credibility" /></td>
<td><img src="image" alt="Credibility" /></td>
</tr>
<tr>
<td>Timeliness:</td>
<td><img src="image" alt="Timeliness" /></td>
<td><img src="image" alt="Timeliness" /></td>
<td><img src="image" alt="Timeliness" /></td>
</tr>
<tr>
<td>Confidence:</td>
<td><img src="image" alt="Confidence" /></td>
<td><img src="image" alt="Confidence" /></td>
<td><img src="image" alt="Confidence" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect:</th>
<th>V.Neg.</th>
<th>Neutral</th>
<th>V.Pos.</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Effect" /></td>
<td><img src="image" alt="Effect" /></td>
<td><img src="image" alt="Effect" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Importance:</th>
<th>Discard</th>
<th>(1)Avg.</th>
<th>(2)High</th>
<th>(3)V.High</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Importance" /></td>
<td><img src="image" alt="Importance" /></td>
<td><img src="image" alt="Importance" /></td>
<td><img src="image" alt="Importance" /></td>
<td></td>
</tr>
</tbody>
</table>
We display/share these assessments using an Information Object (IOB)

Step 1: Select document for retention

Step 2: Activate Abstraction Template

Step 3: Complete Assessment

DCODE Software creates and stores an Information Object (IOB) in designated database
Information Objects (IOBs)

The creation, use and sharing of Information Objects (IOBs) is the key critical concept in DCODE.
An IOB is an iconic encapsulation of the subjective assessments an individual has assigned to a particular information item. It is automatically created from the completed abstraction template. It is analogous to military tactical symbology.
IOB Encapsulation Process

Who originated the IOB

Unique identifier

Importance:
- Discard
- Avg.
- High
- V. High

Hyperlinked to doc.
Effect/Importance Coding

Effect on Criterion is color-coded

**IMPORTANCE**
- Very Negative
- Negative
- Positive
- Very Positive

**EFFECT ON CRITERION IS COLOR-CODED**

- Average
- High
- Very High

Importance “Power bar”

- 2 Squares
- Dark Green

Document is of High Importance and has a Very Positive effect on the Gain Criterion
De-Cluttering the Display

Minimal View (keyword, effect, importance)

Which Item? The Effect? The Importance?

Full View (all parameters) available as a drill-down capability
Why Use IOBs?

- IOBs improves an individual’s decision making ability by simplifying the evaluation of disparate information sources.
Sharing and Integration of Information

Participant’s Individual Display

IOB Sorting/Analysis Techniques

Overall Decision Recommendation:

Give me non-redundant IOBs from other group members

For demonstration purposes, a few of the IOBs are hyperlinked to demo documents/URLs.

History

Recalls

Analysis FROM The Stock Consultant

1997

Sales

Growth Prospects

TreviPark System

VectorVast Analysis

prior contract 2011
DCODE Provides “one-click” sharing of Uniquely Held Information

Information that I have:

- Analysis FROM The Stock Consultant
- Salitis
- VectorVest Analysis
- Recalls
- Growth Prospects
- prior contract
- 1997
- TreviPark System
- prior contract 2/01

"Add Group"

Adds three new group IOBs
“Add Group”

Member already has a high cognitive burden. What is the likelihood these will be integrated into his decision process?

DCODE IOBs Improve the Integration of Shared Information
Key Concepts in IOB Application to Shared Understanding

INFORMATION ABSTRACTION

INFORMATION ENCAPSULATION

INFORMATION SHARING
New Concepts (not in demo)

• Entering personal knowledge
• Encoding Quality of Information
• The “EQI” bar
(1) Internet, Documents, Databases, etc
In 1998 I was involved in a Simulated NEO, and we found that....

Created by: M1 BILL  On: 9/23/03  1705
Information Coding

- Three most critical elements are:
  - Effect/Impact: Color (4 or 5 levels)
    - Color Pattern (2 levels)
  - Importance: Size (3 levels)
  - Quality: Composite of several parameters
    - Quality is Average or Better
    - Quality is Below Average
Coding Quality of Information

Quality is a composite score:

Decision Team sets up a scoring algorithm, e.g. “flag any total score 5 or less”

Quality is Average Or better

Total Score = 6

Quality is Below Average

Total Score = 4
The Effect/Quality/Importance (EQI) Bar

<table>
<thead>
<tr>
<th>AVERAGE IMPORTANCE</th>
<th>Quality</th>
<th>HIGH IMPORTANCE</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Very Pos.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pos.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neg.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. Neg.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>VERY HIGH IMPORTANCE</th>
<th>Quality</th>
<th>Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>?</td>
</tr>
<tr>
<td>Very Pos.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pos.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. Neg.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Do IOBs really help?
PG School Experiment
18 Officers (Summer 03)

- Display: Text vs IOBs
- Decision: Positive vs Negative

<table>
<thead>
<tr>
<th>Decision</th>
<th>Display</th>
<th>N</th>
<th>N (tot)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Text Only</td>
<td>N=5</td>
<td>N=10</td>
</tr>
<tr>
<td></td>
<td>IOBs</td>
<td>N=5</td>
<td></td>
</tr>
<tr>
<td>Negative</td>
<td>Text Only</td>
<td>N=4</td>
<td>N=8</td>
</tr>
<tr>
<td></td>
<td>IOBs</td>
<td>N=4</td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>Text Only</td>
<td>N=9</td>
<td>N=18</td>
</tr>
<tr>
<td></td>
<td>IOBs</td>
<td>N=9</td>
<td></td>
</tr>
</tbody>
</table>

N=10
N=8
N (tot)=18
Task:

- Should we use Islandia as the refugee site?
- Sees 30 information items (randomized)
  - 5 decision criteria
  - 6 items per criteria
The Five Decision Criteria

[COMmunications - TSPortion - LABor - ADMistration - SANitation]

- **Communications Facilities (COM):** Assess the communication facilities that are available in Islandia, including land telephone systems, radio, TV, cellular phone availability and coverage, etc.
- **Transportation Facilities (TSP):** Assess the transportation facilities that are available in Islandia, including roads, docks, airports, etc.
- **Labor Pool (LAB):** Assess the labor pool that would be available to staff the camp in Islandia, including size of the pool, quality of workers, work ethic/tradition, etc.
- **Administrative Requirements (ADM):** Assess the administrative requirements needed to set up the camp in Islandia, including, permits, fees, environmental considerations, bureaucratic red tape, graft, bribes, etc.
- **Sanitation/Health/Medical conditions (SAN):** Assess the sanitation, health and medical conditions expected in Islandia, including drinking water, sewerage disposal, medical facilities, infectious diseases, etc.
...A cultural tradition in Islandia is that each worker is given a single two month vacation each year, which he can take anytime during the year. All the employee has to do is give the employer a one week notice before going on vacation. This has caused unexpected and disrupted work shortages when several employees elect to take the vacation at the same time.

[COMmunications - TSPotation - LABor - ADMinistration - SANitation]

- **Communications Facilities (COM):** Assess the communication facilities that are available in Islandia, including land telephone systems, radio, TV, cellular phone availability and coverage, etc.
- **Transportation Facilities (TSP):** Assess the transportation facilities that are available in Islandia, including roads, docks, airports, etc.
- **Labor Pool (LAB):** Assess the labor pool that would be available to staff the camp in Islandia, including size of the pool, quality of workers, work ethic/tradition, etc.
- **Administrative Requirements (ADM):** Assess the administrative requirements needed to set up the camp in Islandia, including permits, fees, environmental considerations, bureaucratic red tape, grant, bonds, etc.
- **Sanitation/Health/Medical conditions (SAN):** Assess the sanitation, health and medical conditions expected in Islandia, including drinking water, sewerage disposal, medical facilities, infectious diseases, etc.

Read this, then assign it to one of the five criteria

(do 30 of these)
Read this, then:

Assign a keyword
Assign it to a criterion
Evaluate its effect on the criterion

IOB Condition (9 subjects)

The environmental protection effort in Islandia is poorly organized and has had little effect. Environmental impact is not a consideration in any awarding of construction permits.

[COMmunications - TSPortion - LABor - ADMistration - SANitation]

- **Communications Facilities (COM)**: Assess the communication facilities that are available in Islandia, including land telephone systems, radio, TV, cellular phone availability and coverage, etc.
- **Transportation Facilities (TSP)**: Assess the transportation facilities that are available in Islandia, including roads, docks, airports, etc.
- **Labor Pool (LAB)**: Assess the labor pool that would be available to staff the camp in Islandia, including size of the pool, quality of workers, work qualification, etc.
- **Administrative Requirements (ADM)**: Assess the administrative requirements needed to set up the camp in Islandia, including permits, fees, environmental considerations, bureaucratic red tape, graft, bribes, etc.
- **Sanitation/Health/Medical conditions (SAN)**: Assess the sanitation, health and medical conditions expected in Islandia, including drinking water, sewage disposal, medical facilities, infectious diseases, etc.
The major ports of Islandia are less than three days sailing from the primary disaster recovery supply center at Naha. Naha also has three supply ships that are permanently loaded to be used in quick response assistance.

- **Communications Facilities (COM)**: Assess the communication facilities that are available in Islandia, including land telephone systems, radio, TV, cellular phones, availability and coverage, etc.
- **Transportation Facilities (TSP)**: Assess the transportation facilities that are available in Islandia, including roads, docks, airports, etc.
- **Labor Pool (LAB)**: Assess the labor pool that would be available to start the camp in Islandia, including size of the pool, quality of workers, work ethic/tradition, etc.
- **Administrative Requirements (ADM)**: Assess the administrative requirements needed to set up the camp in Islandia, including permits, fees, environmental considerations, bureaucratic red tape, graft, bribes, etc.
- **Sanitation/Health/Medical Conditions (SAN)**: Assess the sanitation, health and medical conditions expected in Islandia, including drinking water, sewage disposal, medical facilities, infectious diseases, etc.

Completed IOB

(does 30 of these)
Decision Tasks:

5 Criteria Decisions,
1 Overall Decision
The items the subject assigned to the Communications criterion

Communications

The environmental protection effort in Islandia is poorly organized has has little effect. Environmental impact is not a consideration is any awarding of construction permits.

A recent disaster simulation exercise in Islandia showed that the Emergency Medical were very inadequate in terms of handling anything other than the smallest disaster situations.

“...The major ports of Islandia are less than three days sailing from the primary disaster recovery supply center at Naha. Naha also has three supply ships that are permanently loaded to be used in quick response assistance...”

Every small town in Islandia has at least one phone

“...The major air route to Islandia is from Chenche. That route, however, requires that we fly over the nation of Gambist, and Gambist has denied permission to fly over their airspace. The two options are to modify the flight plan or to use another departure airport. Both of these options results in excessively long flights, limits cargo capacity, and reduces the daily amount of supplies that can be transported to Islandia.”
Decision Display: IOB

Communications

- 104: \textcolor{red}{77} COM
- 109: \textcolor{red}{99} COM
- 95: \textcolor{yellow}{666} COM
- 114: \textcolor{yellow}{567} COM
- 121: \textcolor{green}{11} COM
- 120: \textcolor{green}{111} COM

Transportation

- 100: \textcolor{yellow}{22} TSP
- 105: \textcolor{green}{775} TSP
- 98: \textcolor{green}{777} TSP
- 91: \textcolor{green}{ports} TSP
- 93: \textcolor{green}{666} TSP
- 92: \textcolor{green}{66} TSP
- 112: \textcolor{green}{777} TSP
- 118: \textcolor{green}{44} TSP

Overall Recommendation

- Very Neg: COM: 3, TSP: 2, LAS: 3, ADM: 2, SAN: 3
- Very Pos: COM: 1, TSP: 1, LAS: 1, ADM: 1, SAN: 1

Click on the hyperlinked titles in the IOB to display the original text here.

Hyperlinked
Positive vs Negative

½ of Subjects should make a decision that is **Positive:**

3 of 5 criteria are Positive

½ of Subjects should make a decision that is **Negative:**

3 of 5 criteria are Negative

Positive Criterion: 4 of the 6 statements are positive
Negative Criterion: 4 of the 6 statements are negative
One Last Request: Please select one of the options below in terms of how useful the IOBs were in making your scoring decision (this would be as versus just seeing the text listing of the items you assigned to each criterion).

<table>
<thead>
<tr>
<th>Somewhat distracting</th>
<th>No Effect</th>
<th>Helped Somewhat</th>
<th>Helped a lot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Submit
RESULTS
IOB subjects took an average 18 seconds longer per item to enter keyword and make evaluation.
Participants took significantly longer to complete the decision process when the predominance of information was positive.
Errors in Criterion Scoring

- Text (includes neutral)
- IOB (includes neutral)
- Text (Reversals only)
- IOB (Reversals Only)

45 Max
ERRORS OVERALL

9 Max

Text (includes neutral)

IOB (includes neutral)

Text (Reversals only)

IOB (Reversals Only)
Overall Ratings

Overall Final Ratings

<table>
<thead>
<tr>
<th></th>
<th>Text</th>
<th>Neg</th>
<th>Neutral</th>
<th>Pos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Errors</td>
<td></td>
<td>6/6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2/2</td>
<td>1/1</td>
</tr>
</tbody>
</table>

0/9 Correct Decisions!

6/9 Correct Decisions!
The Two Display Conditions:

**TEXT**

- Communications
- Transportation

0 out of 9 Correct Overall Decisions

**IOB**

- Communications
- Transportation

6 out of 9 Correct Overall Decisions
IOB Subjective Assessments

- Distract
- No Effect
- Somewhat
- A Lot

Max = 9

IOBs HELP?
Research Summary:

- Decision time same for Text and IOB.
- Decision time longer for positive information.
- Text participants make more reversal errors in scoring individual criteria.
- In making Overall decisions:
  - Text more likely to use Neutral rating.
  - Text more likely to make reversal errors.
  - IOB make more accurate decisions.
- IOB participants feel IOBs are helpful/useful.
Hidden Profile Experiment

- Subjects saw 12 information items, leading to a Positive or Negative recommendation.
- Then saw 10 more items that should cause a reversal in the recommendation.
- Out of 20 eligible subjects, only 7 (35%) detected the hidden profile.
- Shifting from Negative to Positive was significantly more difficult (1 out of 6).
Interface with EWALL project

This news item has a Very Negative impact on the Cost criterion, is of High Importance and is of acceptable/good Quality
Expected Final Products

• A shrink-wrapped software package:
  – Runs in the background on a WAN or LAN
  – Set-up by the assigned decision-task group
  – User-designed abstraction template
  – IOB Generation algorithm
  – Optimized sorting, analysis package
  – Group interactive IOB display area
  – Uses existing COTS audio/visual collaborative system to reduce conflict, reach consensus.
Possible Application areas

• Proposal submitted to Home Land Security:
  – “Information Objects (IOBs): A Knowledge Management Tool for Information Fusion, Correlation And Distribution”

• Proposal submitted to DDR&E
  – “Iconic Abstractions of Subjective Knowledge for Asynchronous Collaboration”

• DCODE briefed to Counter Drug Investigation Center (CIC)
Recent/Planned Publications


• **The Effects of New Information on Decision Modification: The Role of Display Format and Direction of Impact.** SSC-SD Technical Report, in prep, Jan 04.


• **An experimental comparison using text documents versus iconic representations in complex decision making.** SSC-SD Technical Report, in prep., Jan 04

• **Essential information characteristic needed for any retained decision-relevant information item.** SSC-SD Technical Report, in-progress.
IOB On-Line Demo

Available at two sites:

http://64.66.5.34/demo/

http://www.ocf.berkeley.edu/~slinlee/dcode/demo/
Back-up slides
Assigned to DIFFERENT Crit.

Different Criterion
(270 max)

Different Effect
(IOB only, 270 max)
Score Assignment to Criteria

![Graph showing score assignment to criteria]
Scoring Assignments by IOB

IOB Group

0 20 40 60 80 100 120
Research Questions

• What are the critical subjective information assessments (parameters) that each individual assigns to a retained information item?
• How can we quantitatively capture these assessments without placing an undue cognitive burden on the individual?
• How do we best display this captured information to improve the ability of the individual to make an overall assessment of his information pool?
• How do we display, share and transfer this captured information to ensure that the group sees and uses to the entire pool of relevant information to reach consensus on the final overall group recommendation?
Once a group has been assigned a decision making task, they need to determine two critical issues:

- What are the **decision criteria** (factors) that we will use?
  - e.g. Cost, Risk, Duration, etc.
- How many **options** (COAs) are we considering?
  - One (Yes/No, Go/No Go)
    - Should we do A?
  - Multiple COAs
    - Should we do A or B or C or ....?
Template changes only slightly from task to task

Different Decision Tasks modify **only 2 parameters** of the Abstraction Template:

- **Title:**
- **Criterion:**
- **Credibility:**
- **Timeliness:**
- **Confidence:**
- **Effect:**
- **Importance:**

**# of “Effect” rating scales**

**(# of COAs)**

**Buy a Car**
- Volvo: Cost
- Ford: MPG
- Buick: Maint

**Locate a Factory**
- Tampa: Taxes
- LA: Cost
- Dallas: Labor

**Remove Surv. Site**
- Destroy: Assets
- Jam: Time
- IO: Risk
Converting Subjective Assessment to EQI Display

This article is Negative in supporting the decision criterion and is rated of High importance. Some question as to Quality of the information.

This article is Very Positive in supporting the decision criterion and is rated of Very High importance. Information Quality is acceptable/good

This article is Very Negative in supporting the decision criterion and is rated of Average importance. Information Quality is acceptable/good