Deriving Relevant Information From 'Too Much Info'.

Authors:

Barbette Ivery - NAWCAD 4.5
Supporting PMA 290

Joe Schaff - AMEWAS Inc.
Supporting ACETEF

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
APR 2010		**00-00-2010 to 00-00-2010**

4. TITLE AND SUBTITLE	
Deriving Relevant Information From 'Too Much Info'.	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Air Warfare Center,Aircraft Division,NAWCAD 4.5,Patuxent River,MD,20670**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the 22nd Systems and Software Technology Conference (SSTC), 26-29 April 2010, Salt Lake City, UT.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**16**	

Semantics of Information = What Does it Mean?

- Raw data has no “real” meaning.
- Composition (creation of composite data) gives a meaning to the “composite data”.
  - **Traceable via decomposition**
  - **May mean more that its parts – synergy?**
- Framing and data linkages impart some aspects of meaning - i.e. the semantics to the data / metadata via its ***constraints***.

Example:

- **Two or more people have a conversation:**
  - ***several subjects covered***
  - ***numerous facts (= data items) mentioned.***
  - ***some are just opinions, possibly incorrect information.***
- **Now scale upwards - you are at a party:**
  - ***many conversations between two or more people.***

What's a first step?

- ***You do "conversation surfing":***
  - listen to snippets from one conversation, then move to next.
  - observe tone of voice, body language - emotional aspects.
  - gather information, <u>not</u> specific data.

How do we capture the implicit aspects of the conversations?

- ***We assess what we hear:***
  - party perspective – is there a theme (if any), general tone?
  - is there something external to this party that collectively affects the feeling - e.g. the economy?
  - do they "project" a common belief or feeling?
  - how do you form a composite picture of all that transpired in the conversations?
  - What is truly relevant information to take away from the experience?
- Each conversation had a unique flow to it, you were able to capture snippets of it.
  - from snippets you developed your perspective.
  - you want as unbiased as possible within scope.

What if we had thousands of conversations?

- **We would have thousands of functions. That's a problem.**

General Questions on Data – *bounding, framing, coupling, cohesion*

- How does the data fit?
- How does new data “map” to the correct reference frame?
- Does the meaning of the data change when it becomes “framed”?
- Do current methods fully address the semantics of information w.r.t. data?
- How is data constrained?

Information Bounding – Cohesion and Coupling

- Best ***cohesion*** if data is grouped by task, sequence, or communication.
- Worst = logical (function-specific –e.g. radio knob and r.f. packet data) or most-commonly-used. Many data architectures leverage off of logical, etc.
- ***Coupling*** is the dependency of system / sub-element on others. ***Least is best*** .
  - Why? Check out compsci. refs. on program modules, or distributed / ‘cloud’ computing.
    - Also: comm channels, w/ “common” data shared.

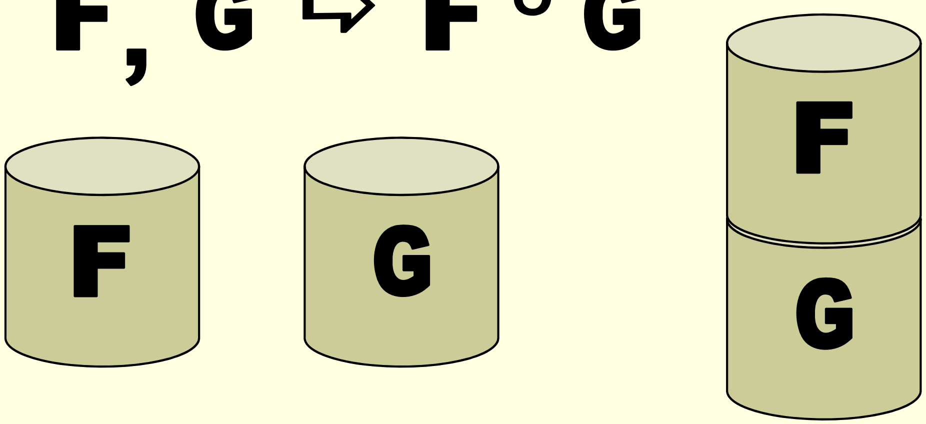
Optimize Coupling and Cohesion

Framing the Data

Creating the frame:

- Define reference frame.
- Relevance within frame.
- Linkages to other reference frames.
- Composite data Boundaries

F, G ⇨ F ° G



Caveats to address:

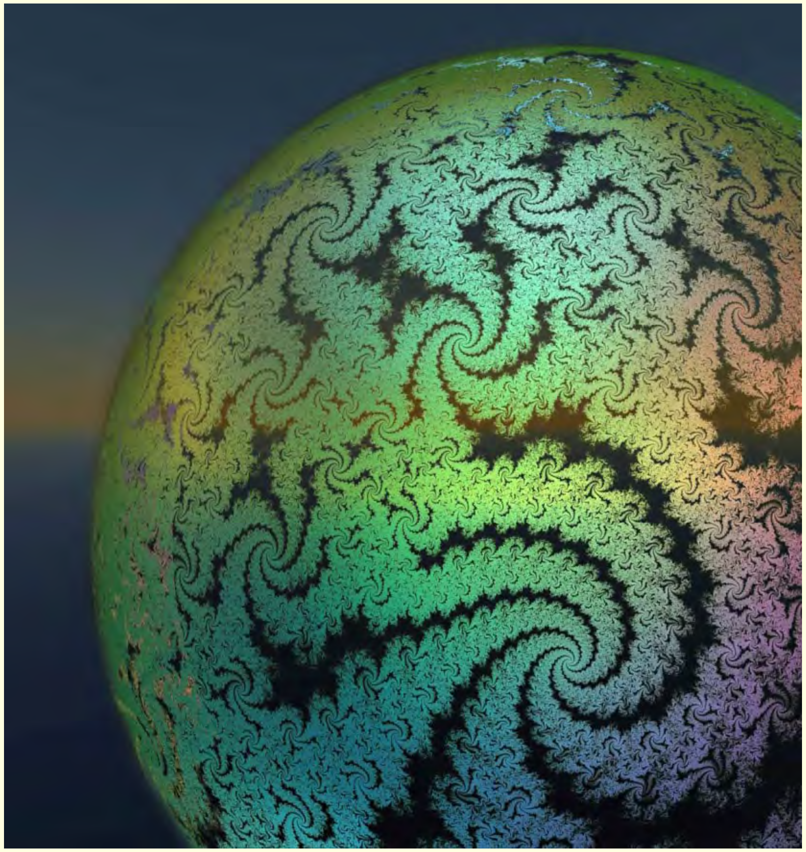
- Composite data may fall outside reference frame - e.g. F and G are both within frame, but F*G may be outside of it.
- Frame boundaries may change.
- Implicit linkages may not be visible.

Current Methods & Way Forward

- Methods include direct interpretation of triples (subject –predicate-object), latent semantics (implied meaning).
- Latent semantics / other methods are prone to error (chirality, causal-chains, etc.).
- Need mathematical formalism w/ consistent mappings.
- Need to capture implicit & explicit relationships between data, both spatial and temporal for cause-effect chains.
- Use clustering & topological mappings to show relationships.
- Use a vector-like construct to capture ‘causal’ linkages between information sets or groups.

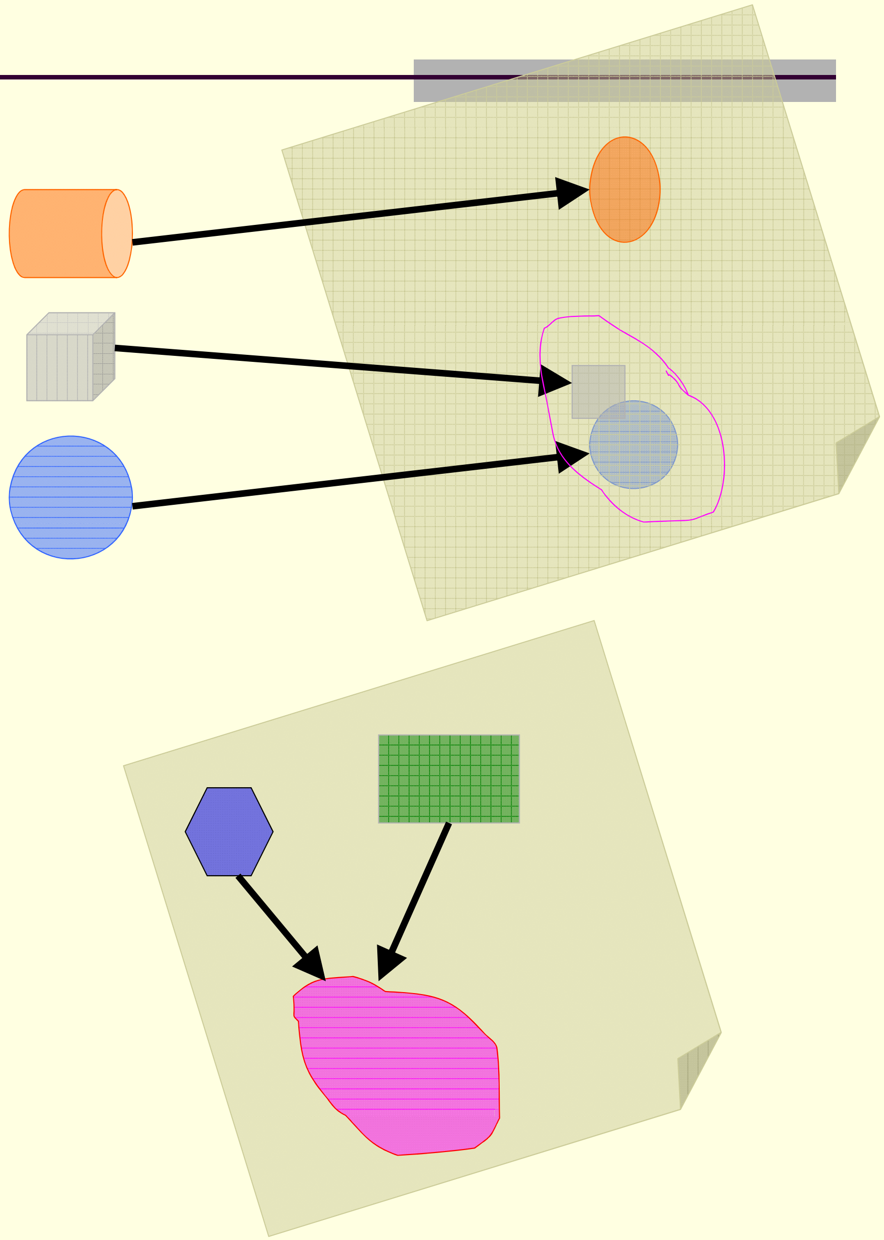
How does it work?

- Each unique “metadata” cluster has information that can be represented by parameters – which we call a function.
- Many of these distributed clusters can be grouped into a “space” of high dimension, typically referred to as ‘n-space’ or Hilbert space (n = number of dimensions).
- The n-space has the sum total of our needed information, but is too complex to work with.
- **Now what???**



How does it work (part 2)?

- We use mathematical topology to our advantage – and *project* the selected relevant information onto a plane.
- This data forms unique shapes that define relationships (e.g. Category Theory).
- We can also link two or more of these shapes to show cause-effects or other time-domain relationships.

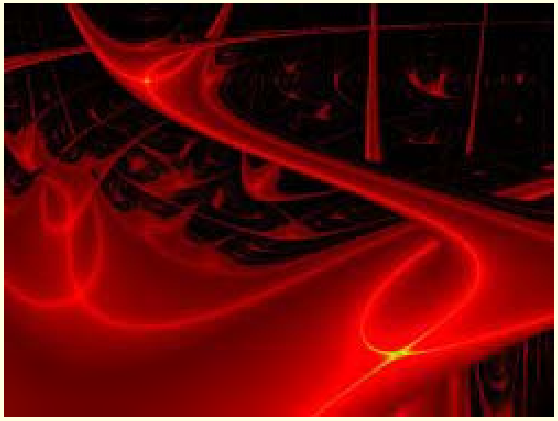


How does it work (part 3)?

From Abstract Mathematics to Language:

- The shapes and their respective ordering relationships form a grammar that describes events, entities, and effects via information flows.
- Now the appropriately framed data has an emergent meaning – i.e. semantics unique to the info-space *perspective*.

This "emergent" semantic perspective can be represented by a mathematical equation which could depict a seemingly abstract shape, below:



Conclusion

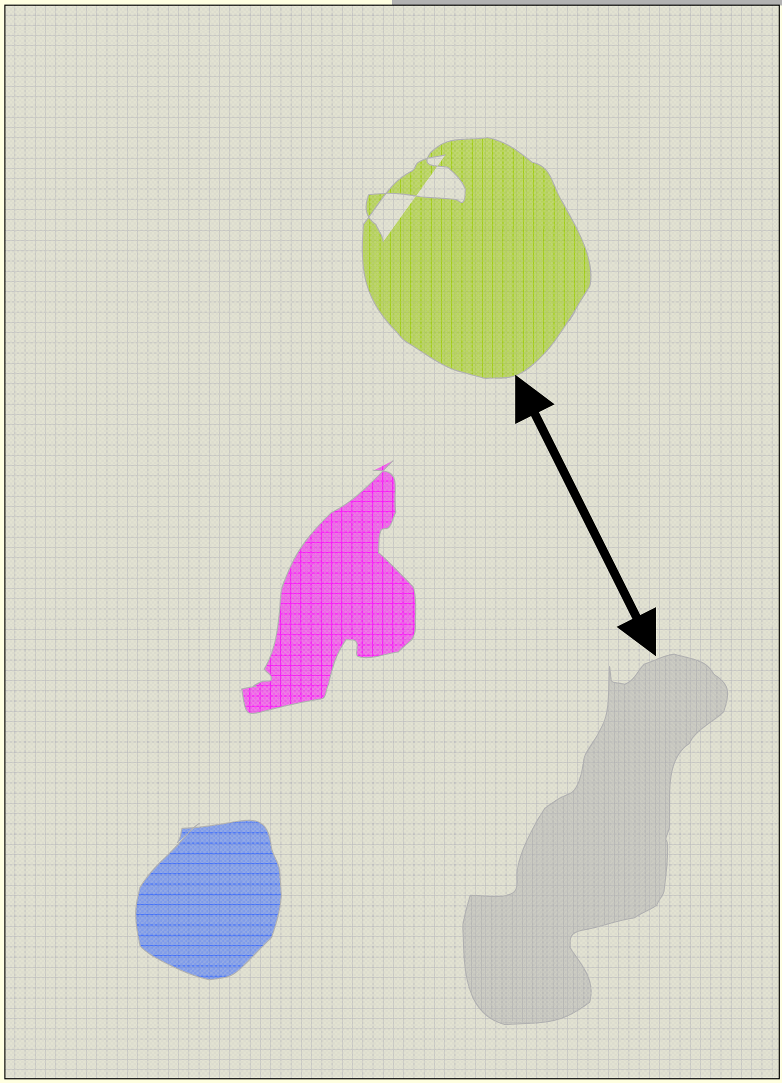
- ***Many applications regarding information validity and relationships. We can now address problems such as:***
  - ***Mitigation of friendly fire***
  - ***Heterogeneous large scale information integration – Army's F.C.S.***
  - ***Readiness metric and overall "Big Picture" (COP) of {capability, availability, dynamic resources effects}***
- Explicit and implicit meaning of data can be defined by selectively bounding clusters to form relevant information.
- Mathematical formalisms give credence to the results, and leverage off of topology.
- Newly 'discoverable' information becomes available due to its emergent properties.
- Both time-domain and causal (cause-effect) information is available using this method of information fusion.

Backup slide: “Comm. Channel”

- A generic communication channel spans the difference in time and in space separating senders from receivers. Comm. channel characteristics are:
  - the physical properties of its medium imposes a constraint on the capacity for communication
  - a specific capacity to store, retain, and transmit certain kinds of signals
  - a sensitivity to non-systematic distortions and decay (noise, etc.)
- A more generalized definition of the comm. channel can be applied to behaviors:
  - Behavior of a system within an environment has effects on other systems in the environment - the environment imposes physical constraints on ‘capacity’ of the system.
  - The capacity to affect or be influenced by effects on a shared behavior channel.

Backup2: Category Theory

- What is it?
  - a means of formally capturing mathematical structures by defining the structure-preserving functions that connect them.
  - Focus on the structure-preserving mappings between groups of objects (called “functors”).
- How does it fit?
  - shape-grammar projections have vectors connecting shapes, showing relational mappings.



Backup3: Barnsley Fern

An iterative Function System (IFS), is generated using the four equations:

$$f(x,y) = \begin{bmatrix} 0.00 & 0.00 \\ 0.00 & 0.16 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

$$f(x,y) = \begin{bmatrix} 0.85 & 0.04 \\ -0.04 & 0.85 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0.00 \\ 1.60 \end{bmatrix}$$

$$f(x,y) = \begin{bmatrix} 0.20 & -0.26 \\ 0.23 & 0.22 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0.00 \\ 1.60 \end{bmatrix}$$

$$f(x,y) = \begin{bmatrix} -0.15 & 0.28 \\ 0.26 & 0.24 \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} 0.00 \\ 0.44 \end{bmatrix}$$