Designing an Effective Graphical Modelling Language
in Information Systems and Enterprise Modeling

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Outline

Domain of Interest / Research Problem
Stakeholders, Concerns, Goals
  Purposes of Modelling
Scope, Orientation, Situation
Modeling Meaning
Communication
Graphical Modelling
Problems
Opportunities
Design
Bigger Issues
Relevance of Research

Organisations are undergoing massive transformative change due to shifts in politics, economy, technology, society, legislation


Modelling can improve the understanding of current situations, problem solving, design of solutions and decision making as to alternatives and priorities

A huge amount of effort expended on modeling but possible benefits not always achieved. Many reasons, but one which we choose to focus on is the choice of, design of and efficacy of visual languages/ graphical models used in enterprise transformation and information systems

The goal is to improve the return on modeling effort (ROME) by improving ease of use, understanding of models, insights gained and efficiency of usage

A sub-goal is to provide insights into the support required in meta models and tools to achieve the primary goal
The Research Problem

Visual Languages (Concrete Syntax) in Enterprise Modeling and Information Systems are often poorly designed.

- Arbitrary symbols are chosen without good rationale e.g. UML, Archimate
- Notations can be overwhelming, intelligible only to experts with extensive training e.g. BPMN, DEMO
- Human cognitive capabilities are not well exploited. Not considered / not using latest research
- Models often become large and hide important information e.g. BAIN, ERP Data Models, Application Landscapes

Opportunities for enhancing comprehension, insight and decision making are lost.

How can we

- Design better visual languages?
- Reduce effort in creation and subsequent use of models?
- Modify the languages at usage time to improve insights and decision making?
- Better exploit the capabilities and overcome limitations of the human visual /cognitive system?
Situating Research

Enterprise Transformation

Enterprise Modelling

Graphical Modelling

Analysis, Discovery & Decision Making

Visual and Cognitive Effectiveness

Visual Language Design and Modification

Design Time

Usage Time
Effectiveness

Defining:
The extent to which models help stakeholders achieve their purpose with minimum effort and delay

Achieving:
Address Domain Concepts
Address Stakeholder Needs/Background/Questions/Intent
Capture Knowledge
Support Analysis
Communicate / Convince
Tool Support
Community Acceptance
Who?

First we need to know who the Stakeholders are

Who has the essential information?

Who will author the models?

Who will review and analyse the models?

Who will approve and publish the models?

Who should be persuaded by the models?

Stakeholder Management Techniques
Stakeholders and Concerns

And then we need to meet their needs

What is their orientation?

What are they familiar with?

What is their level of literacy wrt models / notation format?

What are their concerns?
Domains

Represent areas of (specialised) knowledge

e.g. Healthcare, Education, Retail, Banking, Manufacturing, Astronomy

They have special vocabularies e.g. Patient, Prescription, Treatment, Formulary etc.

Can enhance speed and accuracy of communication for those in the know

But can be a barrier for those who don’t know the language
Why

What is the purpose of the models?
What decisions should they support?
What insights do we wish to obtain?
What should they achieve?
Bloom’s Taxonomy

- **Remember**: Recall facts and basic concepts
  - define, duplicate, list, memorise, repeat, state

- **Understand**: Explain ideas or concepts
  - classify, describe, discuss, explain, identify, locate, recognise, report, select, translate

- **Apply**: Use information in new situations
  - execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch

- **Analyse**: Draw connections among ideas
  - differentiate, organise, restate, compare, contrast, distinguish, examine, experiment, question, test

- **Evaluate**: Justify a stand or decision
  - appraise, argue, defend, judge, select, support, value, critique, weigh

- **Create**: Produce new or original work
  - design, assemble, construct, conjecture, develop, formulate, investigate

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Models as Language

Language is uniquely Human

Some say language is what makes us human

It is what allows us to communicate effectively and share goals, thoughts, feelings, ideas, designs...

Language can be spoken, written and drawn

Models represent a powerful kind of language

From Physics of Notation to Grammar of Models
Language

A way to communicate between parties

A way to communicate precisely between parties using an agreed vocabulary and grammar

A way to communicate precisely between parties using visual symbols, connectors, containers and their arrangement following an agreed notation, representation and (potentially) layout
Language

- Has nouns to communicate about objects and ideas
- Adjectives to describe the nature of objects and ideas
- Verbs to convey action
- Adverbs to modify the action in some way
- Proper names and pronouns to identify actors
- Connectors to join ideas together
- Structure to help users communicate more easily (encoding and parsing)
- Punctuation to group, separate and clarify

Image Credit: Charity Mathew Phillipose
User / Language / Purpose
Communication Model

Claude Shannon & Warren Weaver, 1949

- Entropy
- Redundancy
- Noise
- Channel Capacity/Bandwidth
What is the domain of interest?

What are the relevant concepts?

How standard are they?

Are there already well accepted models and/or notations?

What questions do we want to answer?
When

Under what conditions will the models be produced?

What constraints are there on time, resources, location, participation, tooling etc.?

How will the models be updated and how much of a requirement is this?

How current must the information be?

Are the models supporting future: Strategy, Architecture, Design?
How

Who has the information?

What form is it in?

What is the most effective way to gather it?

How should it be stored, shared, secured?

How should it be analysed, reported, represented, queried?

What notation(s) is(are) appropriate?

What skills are required of the modellers?
Defining Semantics of Domain

We need a semantic layer to express the concepts, properties, relationships, constraints and knowledge of the domain

In a way that captures meaning independent of language, tools and representation

This is essentially a rich data model schema

Hence a competent meta model or semantic model (e.g. OWL) is appropriate
Meta Model Components

- Model Management
  - Stakeholder and Requirements
  - Semantic Model
  - Representation Model
- Instance Semantic Models
- Instance Visual Models
- Meta Meta Model and Technology Adaptation
Combining Domains / Languages

Domains and languages may have overlapping concepts e.g.

Process Models will mention data that is referenced, recorded or updated
Goal Models are tied to Organisation Units that are responsible for their achievement
Capabilities are linked to Applications which support their achievement

We want a properly resolved semantics that allows sharing data where relevant and using concepts and naming consistently across communities

We thus want a single, extensible meta model that can evolve with new requirements and language requirements

We also need the ability to retain naming from imported models / stakeholder community, hence aliases
MEMO Language Architecture

Ulrich Frank and colleagues
Univ Duisburg-Essen
Multiple Perspectives and Layers in MEMO

Ulrich Frank
and colleagues
Univ Duisburg-Essen
Multiple Overlapping Perspectives

Strategic View

Process View

Application View
Layers of Models

- Technical Model
- Polymetric Specs
- Representation Model
- Logical Model Type
- Meta Model

- Executive Model
  - Innovation to support multiple representations of same semantic model including renderings
  - Instances in Repository

<table>
<thead>
<tr>
<th>Process</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>A1</td>
</tr>
<tr>
<td>P2</td>
<td>A2</td>
</tr>
<tr>
<td>P3</td>
<td>A3</td>
</tr>
<tr>
<td></td>
<td>A4</td>
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</table>

<table>
<thead>
<tr>
<th>Process</th>
<th>Application</th>
<th>Data Collection</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>T1</td>
<td>D2</td>
<td>T2</td>
</tr>
<tr>
<td>D2</td>
<td>T3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Meta Meta Model

Competent technique required to define the Meta Models for the various visual languages

Requires definition of semantics as well as the visual aspects of the language and the mapping between these

Approaches which seem inadequate: UML/MOF, ECore, Eclipse GMF

Approaches which are competent: MEMO MML; Clark(Meta Circular Kernel - used in XModeler); EVA/Inspired; MetaEdit+; Smalltalk plus enhancements
Semantic Meta Model

- Show Alias
- Relationship Types
- Property Types
- Generalise named thing
- Ontology
- Taxonomy
- Views (incl for derivation from different lang.)
Rich Data Types

We have found these very powerful in the current EVA Netmodeler tooling.

Essentially we implement a base environment (Smalltalk Class) with a predefined protocol and associated interface widgets for composing user interfaces.
Relationship Types

- Relationship Types
  - Gen / Spec
  - Whole / Part
  - Containment
  - Role
  - Association
  - Classification
  - Instanciation
  - Responsibility / Roll Up
  - Realisation
  - Dependency
  - Sequence

Unspecified

- Relationship Type
  - Generalise-Specialise
  - Contains PartOf
  - Precedes Follows
  - HasRole-RoleOf
  - Classifies-ClassifiesBy
  - InstanceOf-HasInstance
  - DependsUpon-HasDependant
  - Aggregates-IncludedIn
  - References-References
  - ViewOf-HasView
Designing Notation

Things to Avoid / Overcome

- Poor Communication
- Overloading Model Reader
- Ambiguity
- Wasted Effort

Things to Achieve / Exploit

- Leverage Human Capabilities
- Facilitate Tool Support
- Clarity / Accuracy
- Efficiency
Physiology of Human Vision System

Three-stage model of visual information processing - Ware, 2013
Pre-Attentive Processing

Pre-attentive processing illustration - (Ware, 2013)
BPMN 2.0
“Wimmelbild”

by Frank Puhlmann frapu.de

although this one is produced tongue in cheek, it does illustrate the problem for non-experts!
A “Camouflage” Model

and its just a fragment...

Part of the SAP Project Module

Polymetric Examples in SW Eng.

Figure 5.21: A class blueprint visualization of an inheritance hierarchy with the class *JunColorChoice* as root class. Each subclass contains a pure *Siamese Twin* pattern.

Figure 3.2: The *System Complexity* view. This visualization of classes uses a tree layout. The edges represent inheritance relationships. The metrics we use to enrich the view are NOA (the number of attributes of a class) for the width and NCM (the number of methods of a class) for the height. The color shade represents WLOC (the number of lines of code of a class).
Bertin identified 8 variables onto which information can be encoded in a symbol. Each has limits of discrimination.
## Types of Symbols

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
<th>Example</th>
<th>Visual Processing Effort</th>
<th>Translation Effort</th>
<th>Design Effort</th>
<th>Acceptable To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Realistic</td>
<td>Reasonably high definition</td>
<td>Photo, Scan</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>All Users</td>
</tr>
<tr>
<td>Iconic</td>
<td>Reduced image Recognisable</td>
<td>Road Sign Emoji</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>All Users</td>
</tr>
<tr>
<td>Sensory Code</td>
<td>Triggers same visual mechanisms as real objects</td>
<td>Picasso Line Drawing</td>
<td>Low</td>
<td>Low</td>
<td>Very High</td>
<td>Most Users</td>
</tr>
<tr>
<td>Arbitrary</td>
<td>Symbol is abstract and meaning must be learnt</td>
<td>Archimate Role</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Expert Users</td>
</tr>
</tbody>
</table>
Moody proposed a Physics of Notation as a scientific model to guide the design of symbols and graphical notations.

- **Semiotic Clarity** (1 concept, 1 symbol)
- **Perceptual Discriminability** (easy to tell apart)
- **Semantic Transparency** (easy to identify meaning)
- **Complexity Management** (limit complexity, break up etc.)

- **Cognitive Integration** (guide viewer by e.g. layout, arrows)
- **Visual Expressiveness** (use full gamut of capabilities)
- **Dual Coding** (use graphic complemented by text)
- **Graphic Economy** (only enough notation to convey meaning)
- **Cognitive Fit** (use symbols appropriate to audience/viewer knowledge and skill level)
## Cognitive Load

<table>
<thead>
<tr>
<th>Name</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miller</td>
<td>Limits of short term memory</td>
</tr>
<tr>
<td>Ware</td>
<td>Visualisation, Cognition, Awareness</td>
</tr>
<tr>
<td>Melamed</td>
<td>Optimisation of Visual Attention, Layout, Navigation Devices</td>
</tr>
<tr>
<td>de Kinderen</td>
<td>Comparisons between casual and professional model users</td>
</tr>
</tbody>
</table>
Representation Meta Model
Contribution

Transfer of knowledge from human cognition / visual perception research to visual design in IS languages

Innovation WRT Polymetric Diagramming and techniques to facilitate analysis / insights / rapid query. Transfer from SW Engineering discipline to Enterprise Modeling. (Extension of Physics of Notation concepts)

Meta Model to capture abstractions and facilitate successful tool building

Descriptive (Level 4) Theory building in how modifications to visual models affect users

Prescriptive (Level 5) Theory building into Guidance to researchers / practitioners on visual language design incorporating modifications to support discovery

Subtle learning from Prototyping and Expert feedback to inform approach and tool building
References

Alturki, Ahmad, Guy G Gable, Wasana Bandara, and Shirley Gregor. “Validating the Design Science Research Roadmap: Through the Lens of “the Idealised Model for Theory Development”.” PACIS 2012 (2012);


vd Linden D, Hadar I. “Cognitive effectiveness of conceptual modeling languages: Examining professional modelers”. Engineering (EmpiRE) 2015


Camouflage Lion Photo: https://fbcdn-sphotos-c-a.akamaihd.net/hphotos-ak-frc3/971650_533671470011763_1499037240_n.jpg

Code City example: http://www.moosetechnology.org/docs/visualhall

Mondrian Scripting Example: http://www.moosetechnology.org/docs/demos
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