Modelling Languages:
(mostly) Concrete (Visual) Syntax

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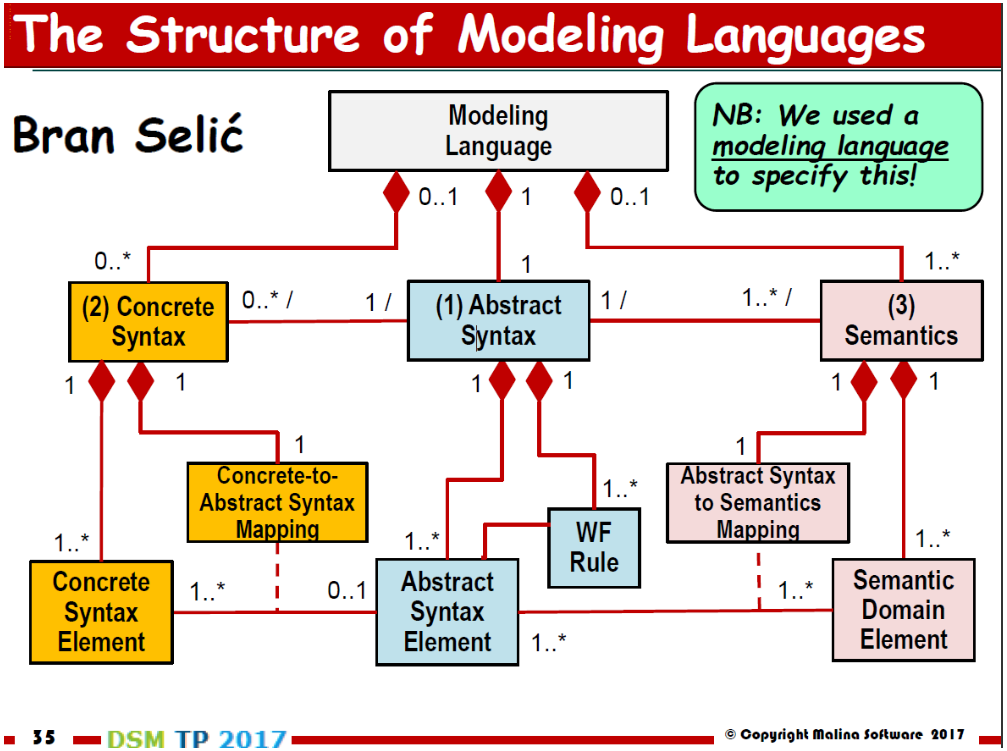
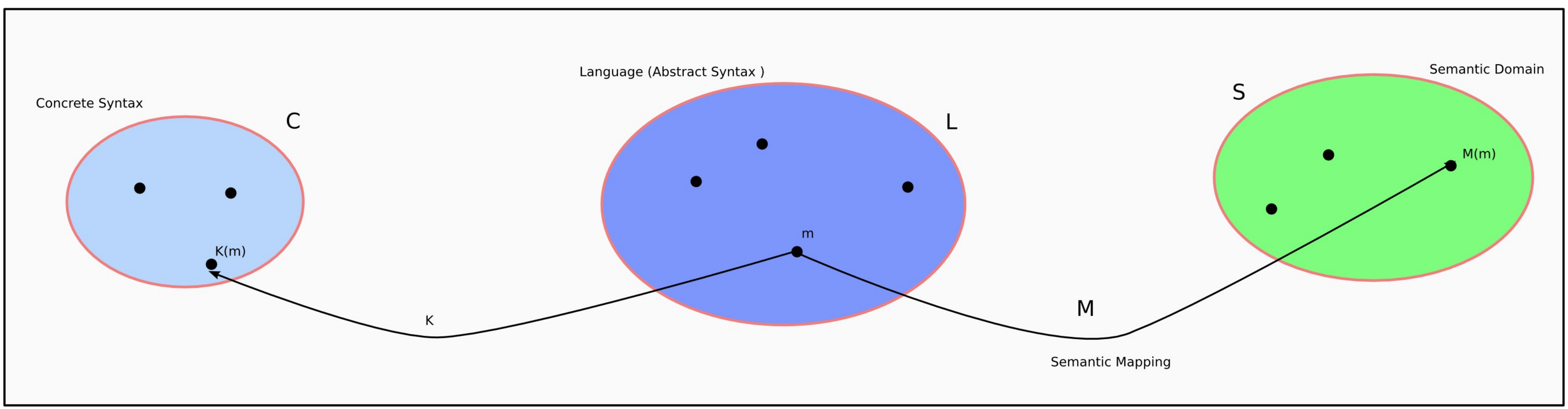
University of Antwerp

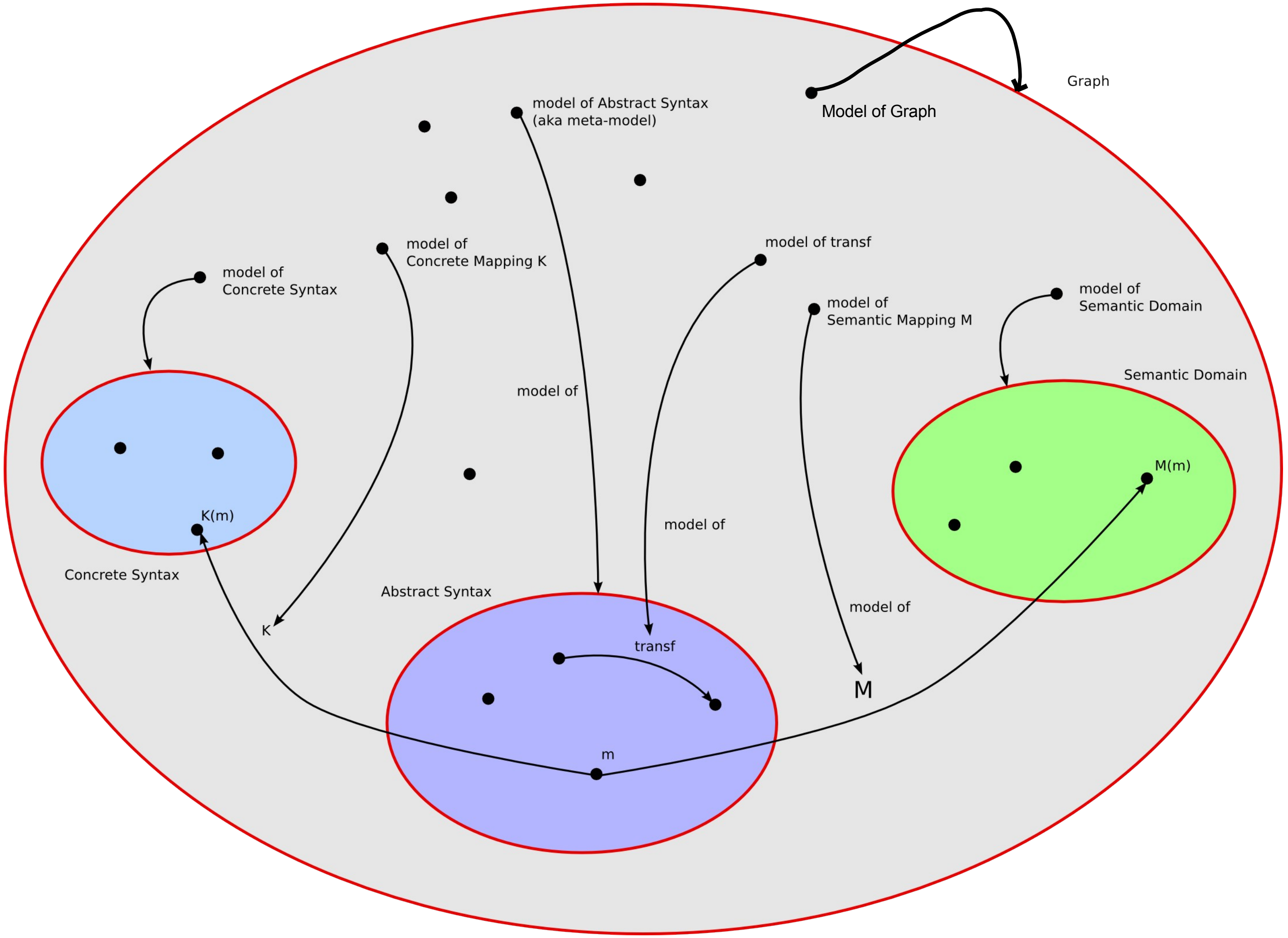
FLANDERS MAKE
MANUFACTURING INNOVATION NETWORK

McGill



Concrete Formalism F




Graph
Model of Graph
model of Abstract Syntax
(aka meta-model)
model of
Concrete Mapping K
model of transf
model of
Concrete Syntax
model of
Semantic Mapping M
model of
Semantic Domain
Semantic Domain
model of
K(m)
M(m)
model of
Concrete Syntax
Abstract Syntax
K
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M
m

Textual Languages

“this sentence is very short”

- Individual <u>letters</u> in an **alphabet**
- Combined into <u>words</u>
- Combined into <u>sentences</u> in a **language**

- Valid <u>letters</u> in <u>words</u> *specified* by **regular expressions**
- Valid <u>words</u> in a <u>language</u> *specified* by a **grammar**

- letters/words are combined by “is to the right of”

The Spoofax Language Workbench

Report TUD-SERG-2010-014a

Rules for Declarative Specification of Languages and IDEs

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Eelco Visser
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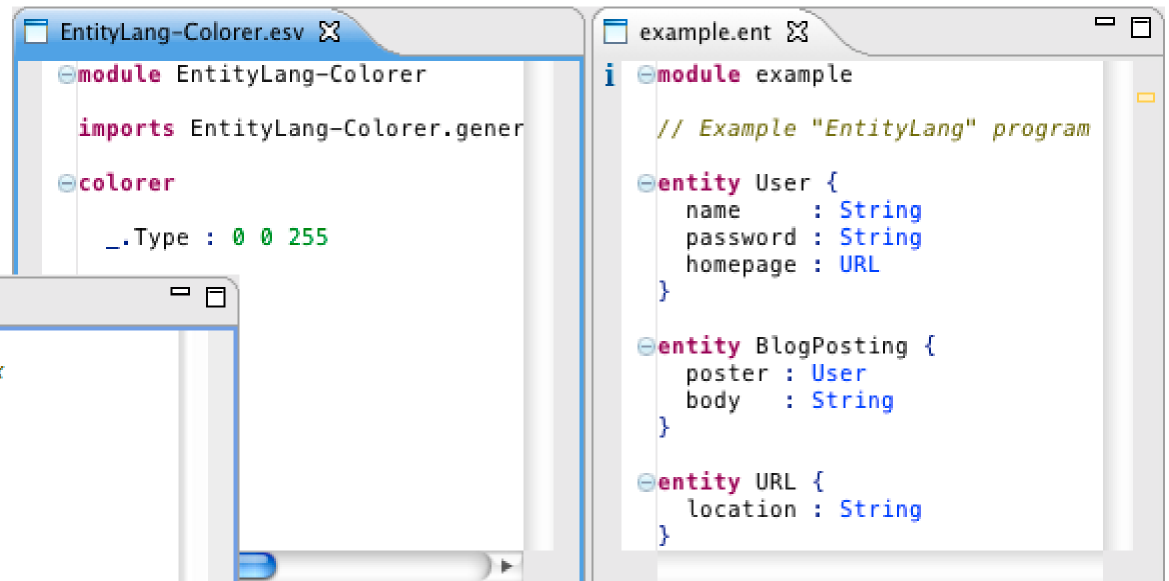
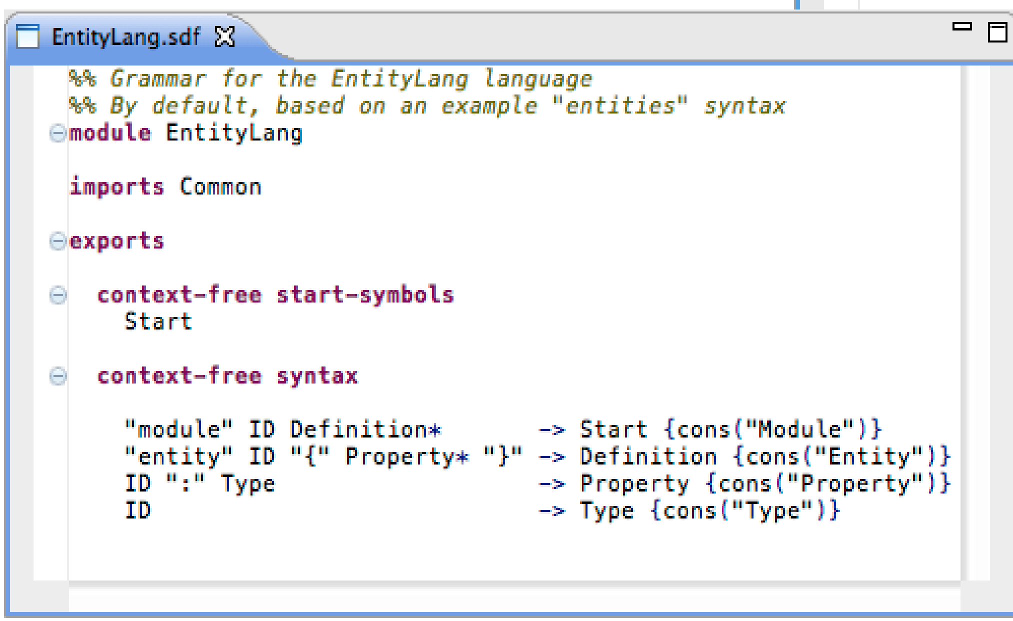
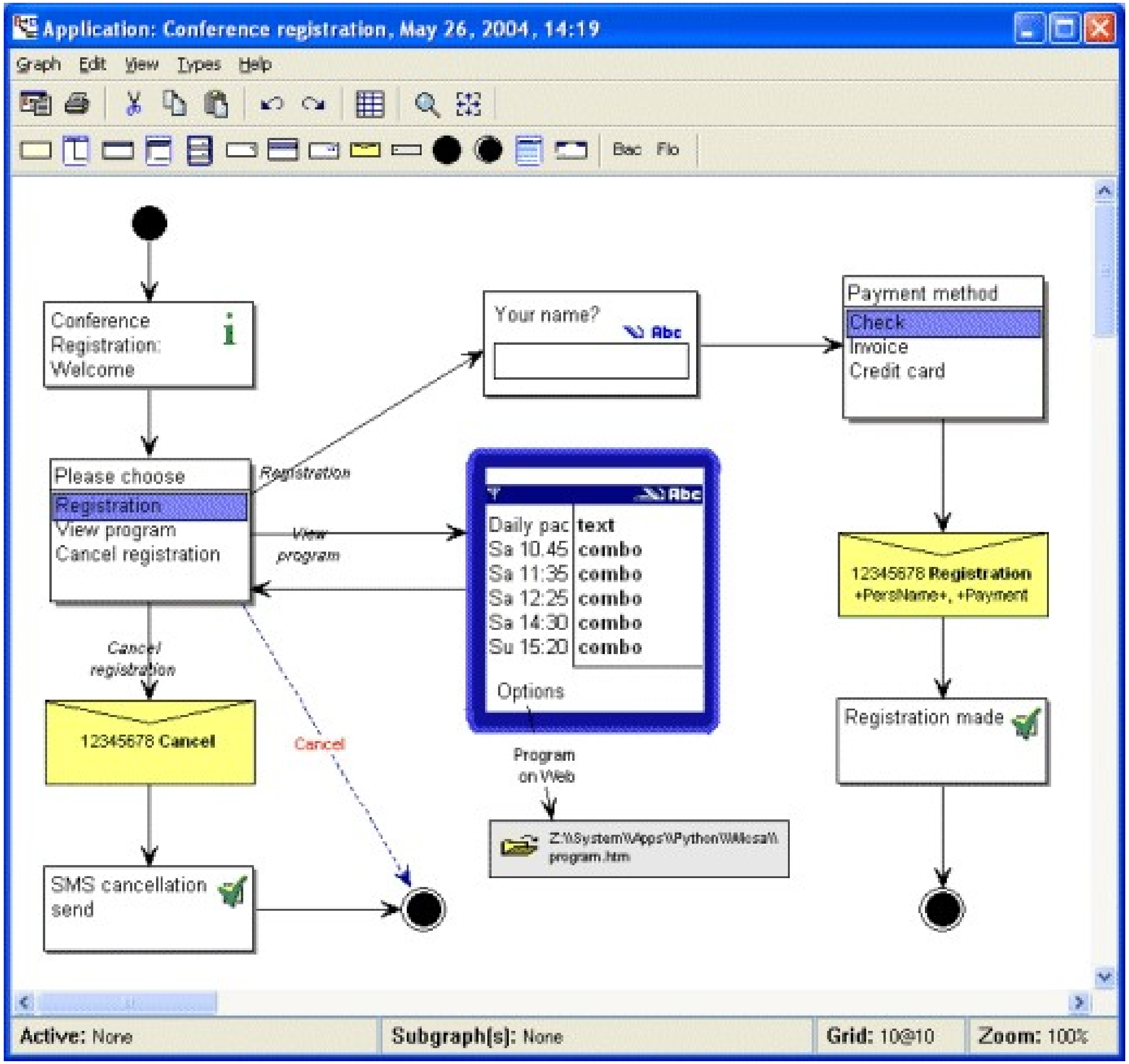




syntax-directed editor
(textual concrete syntax)

syntax-directed editor
(visual concrete syntax)

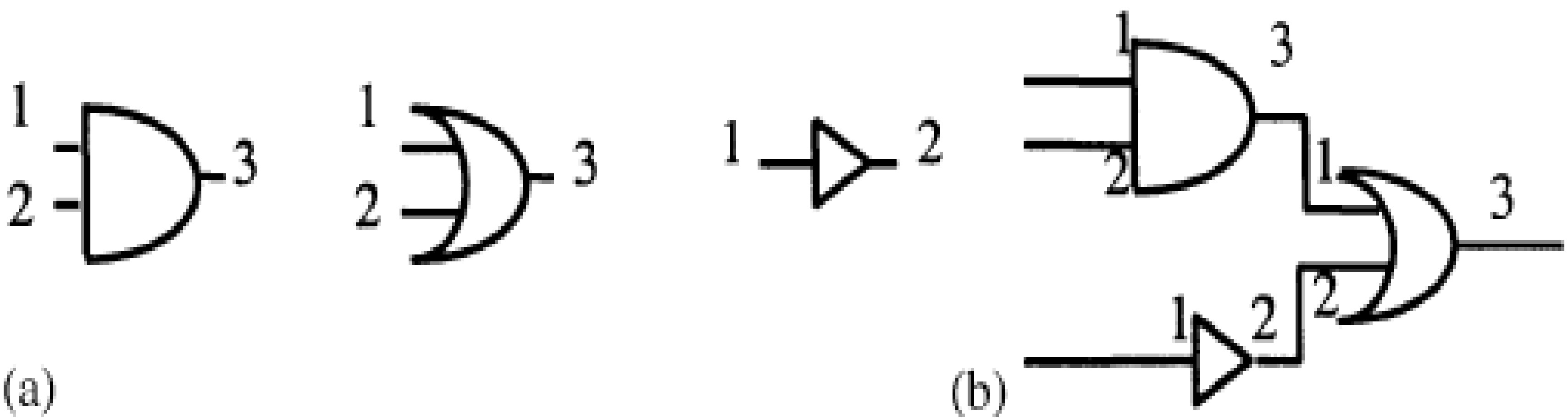


Journal of Visual Languages and Computing (2002) **13**, 573–600
doi:10.1006/S1045-926X(02)00025-3 available online at http://www.idealibrary.com on IDEAL®

A Classification Framework to Support the Design of Visual Languages

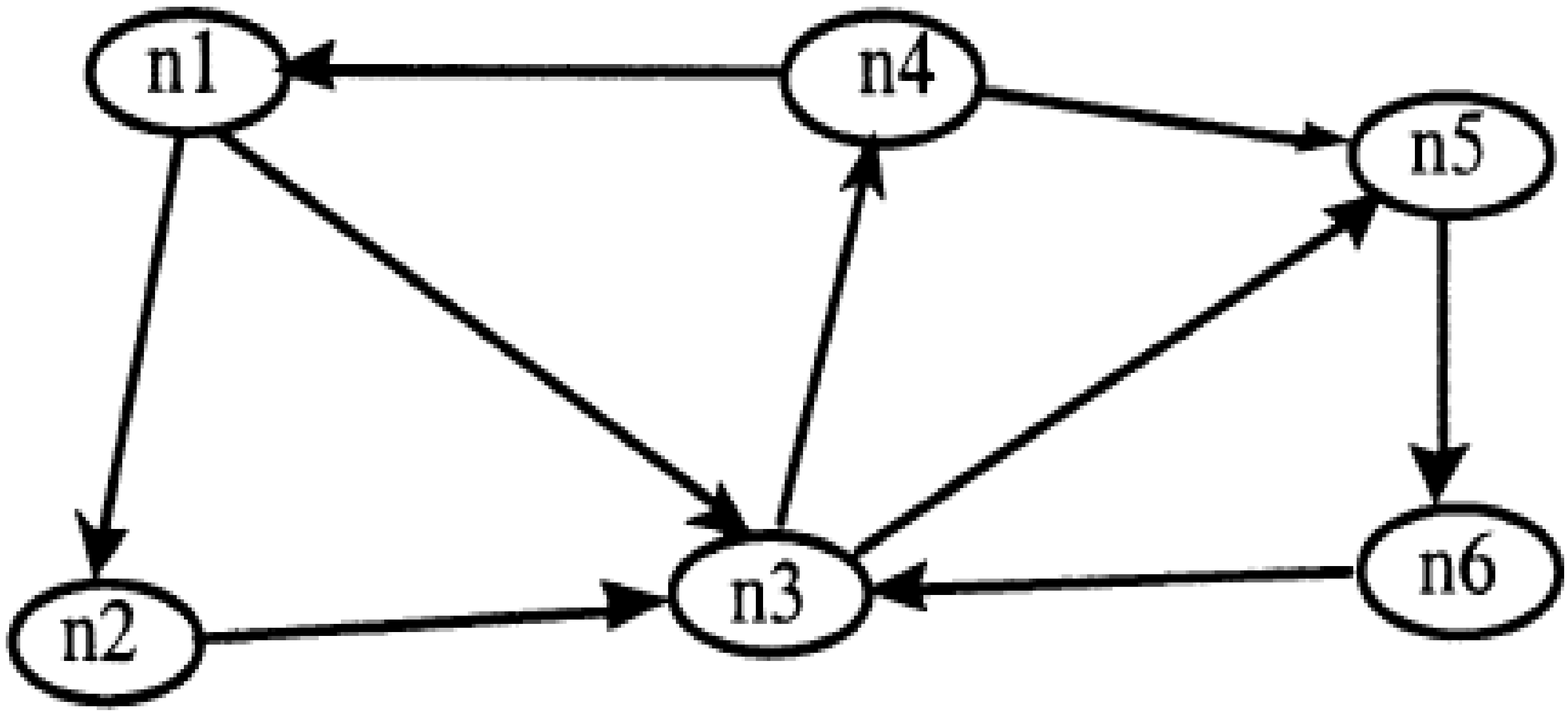
G. Costagliola*, A. Delucia†, S. Orefice‡ and G. Polese*

Plex

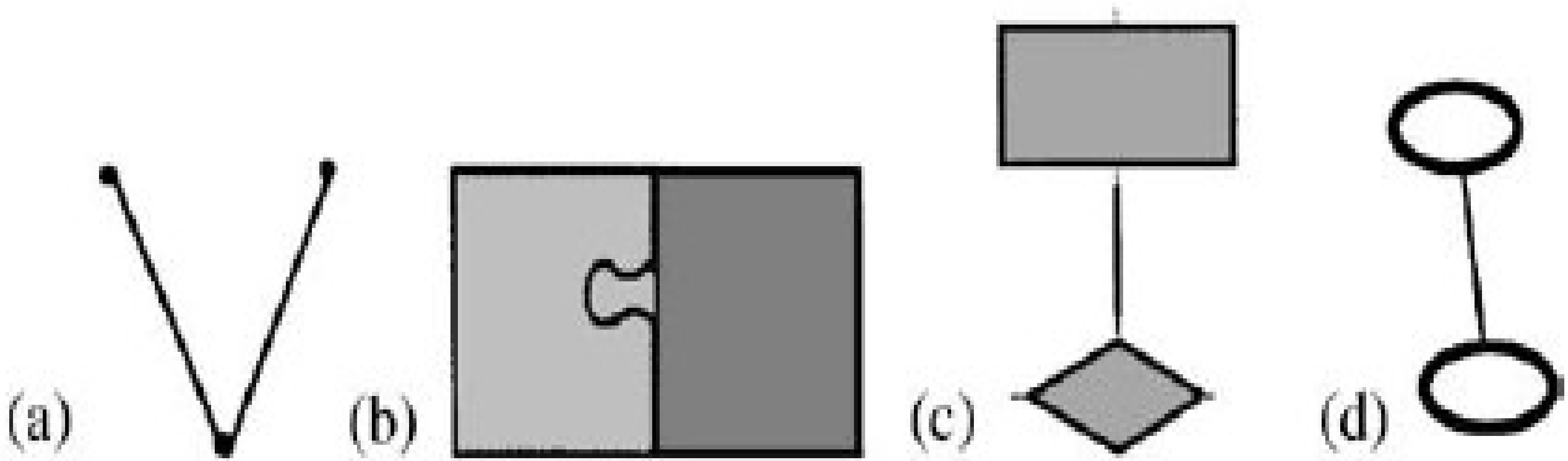


(a) (b)

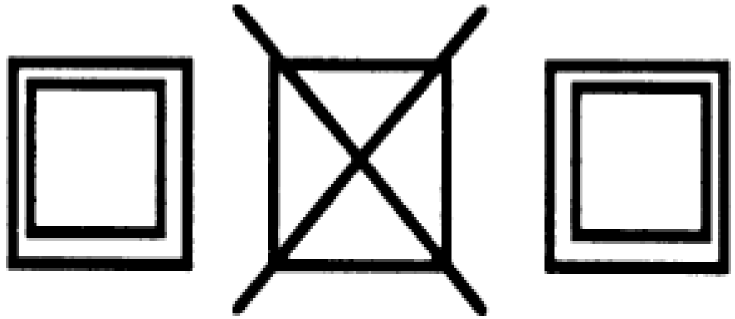
Graph

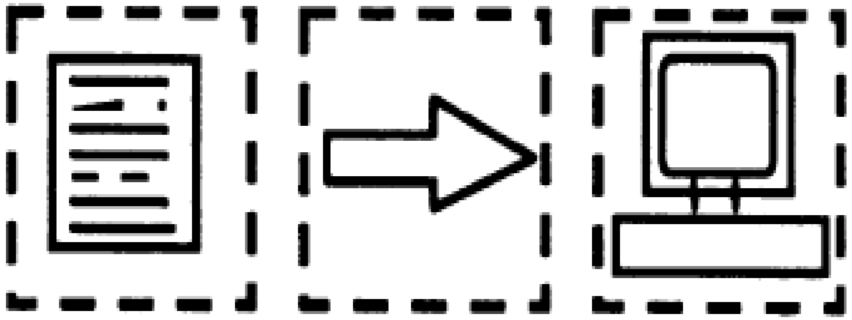


Connection Types



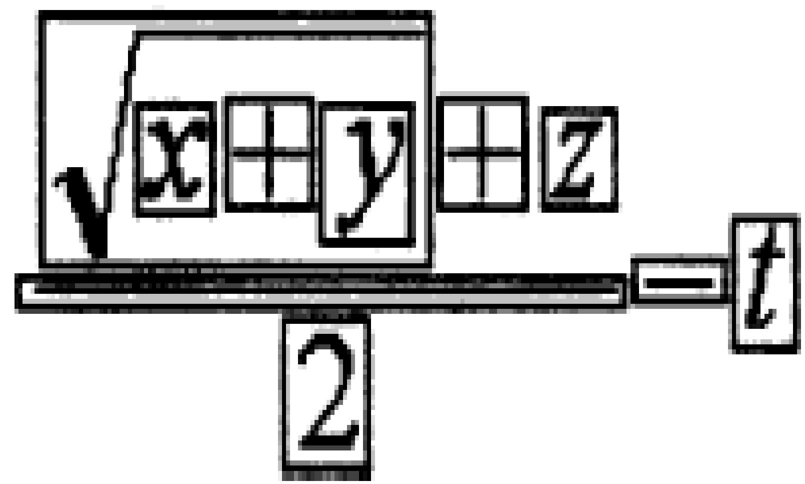
Iconic



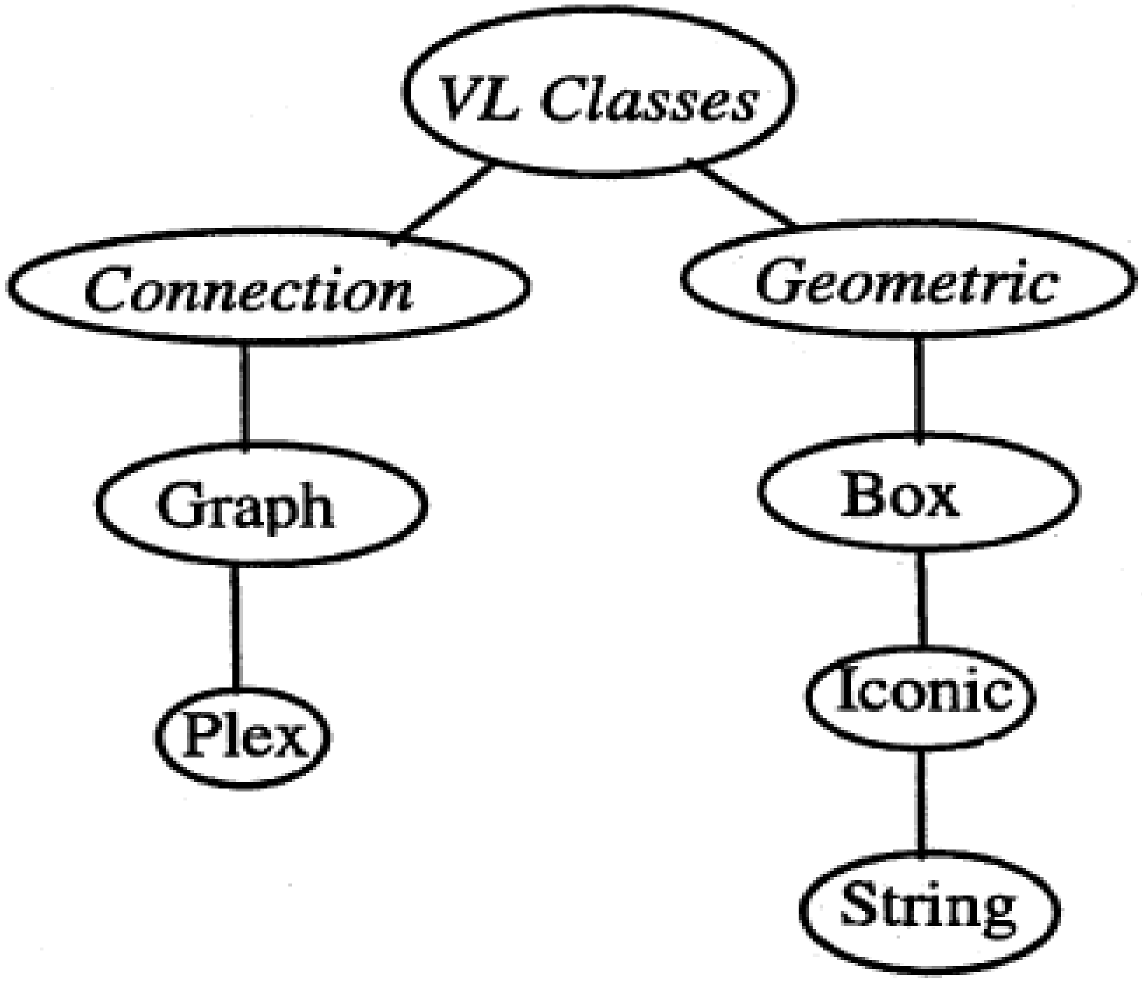


Box

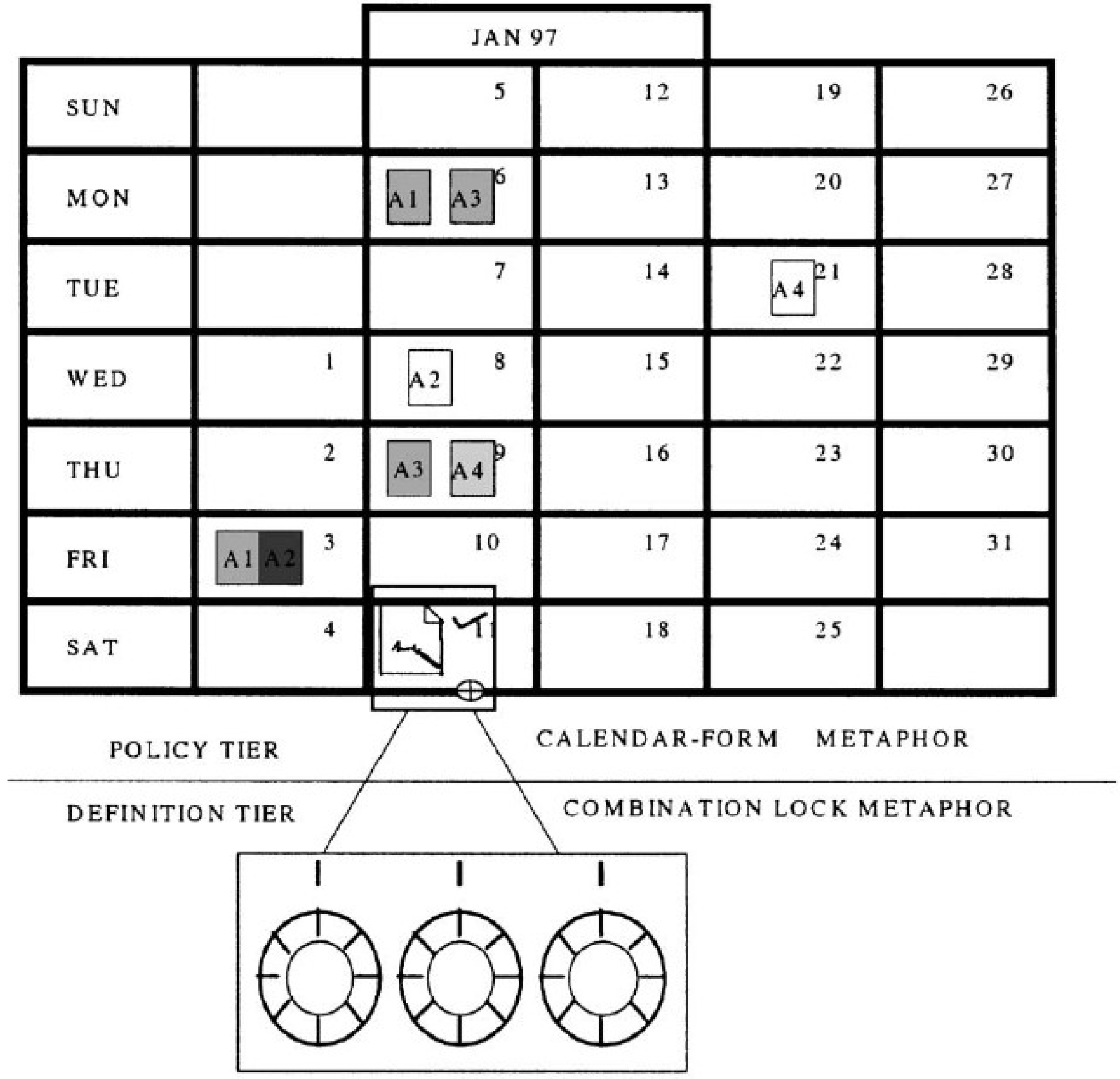
$$\frac{\sqrt{x+y}+z}{2}-t$$



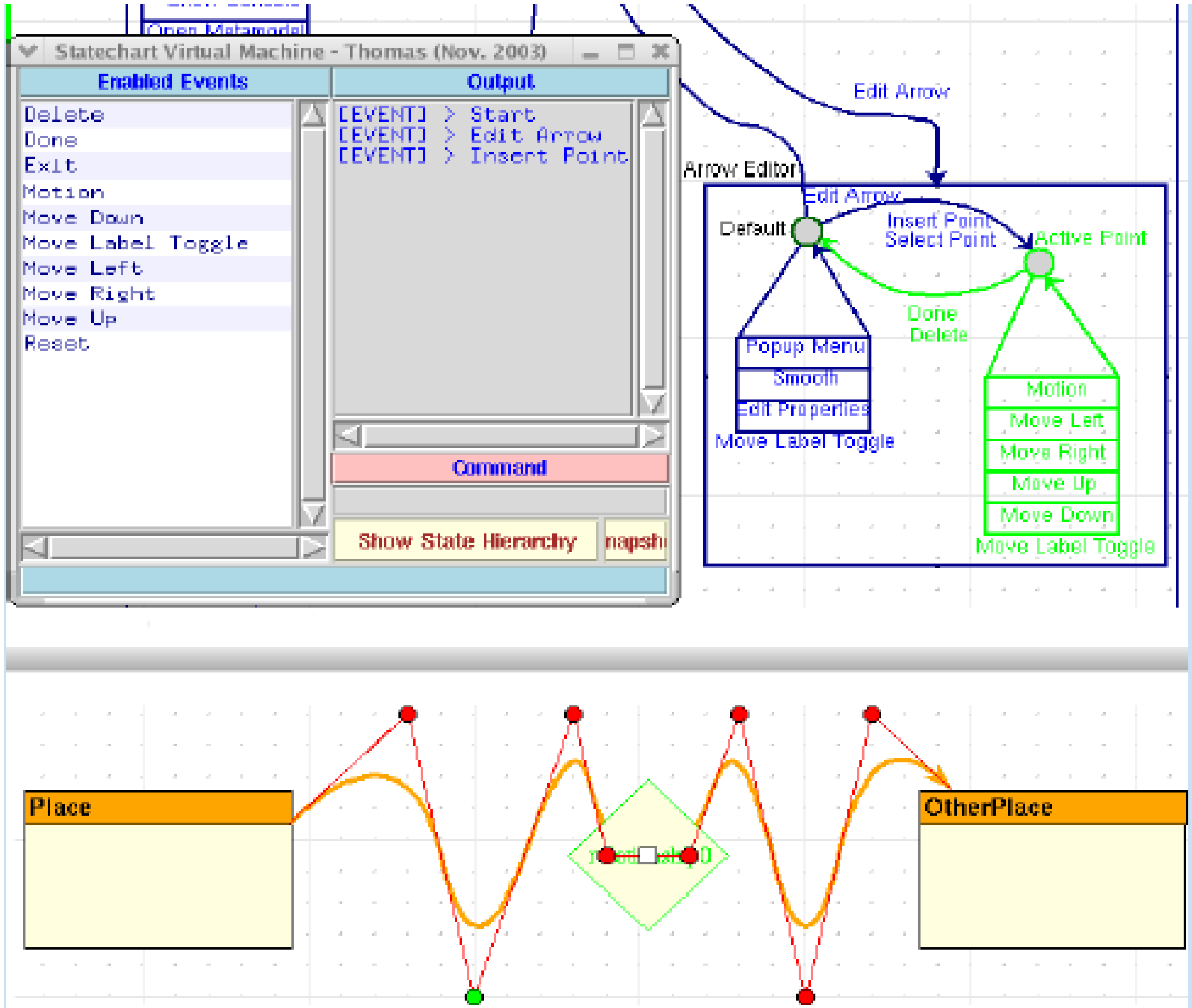
Visual Language Classes



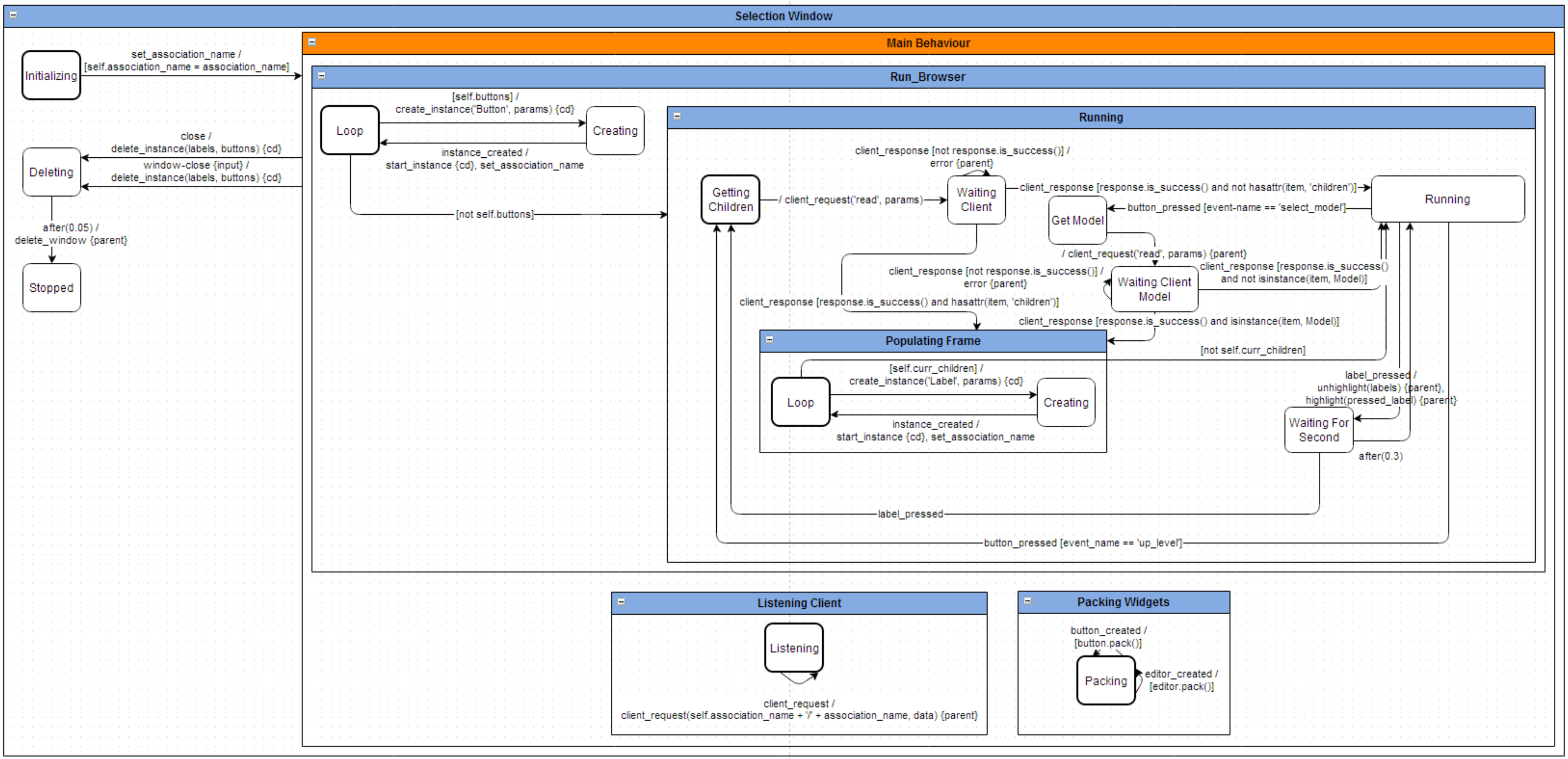
Hybrid Languages



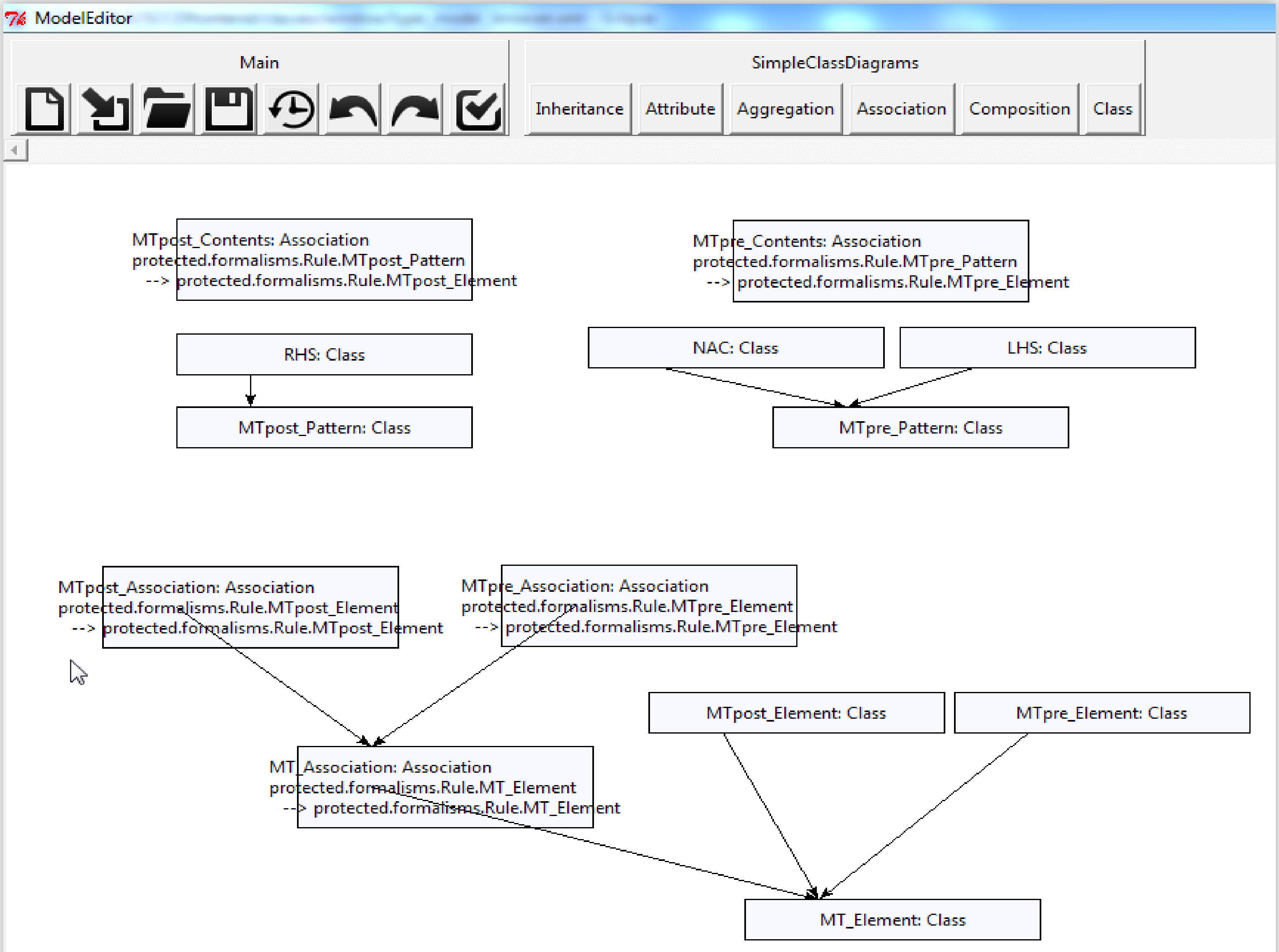
Syntax-directed Visual Editors: model behaviour



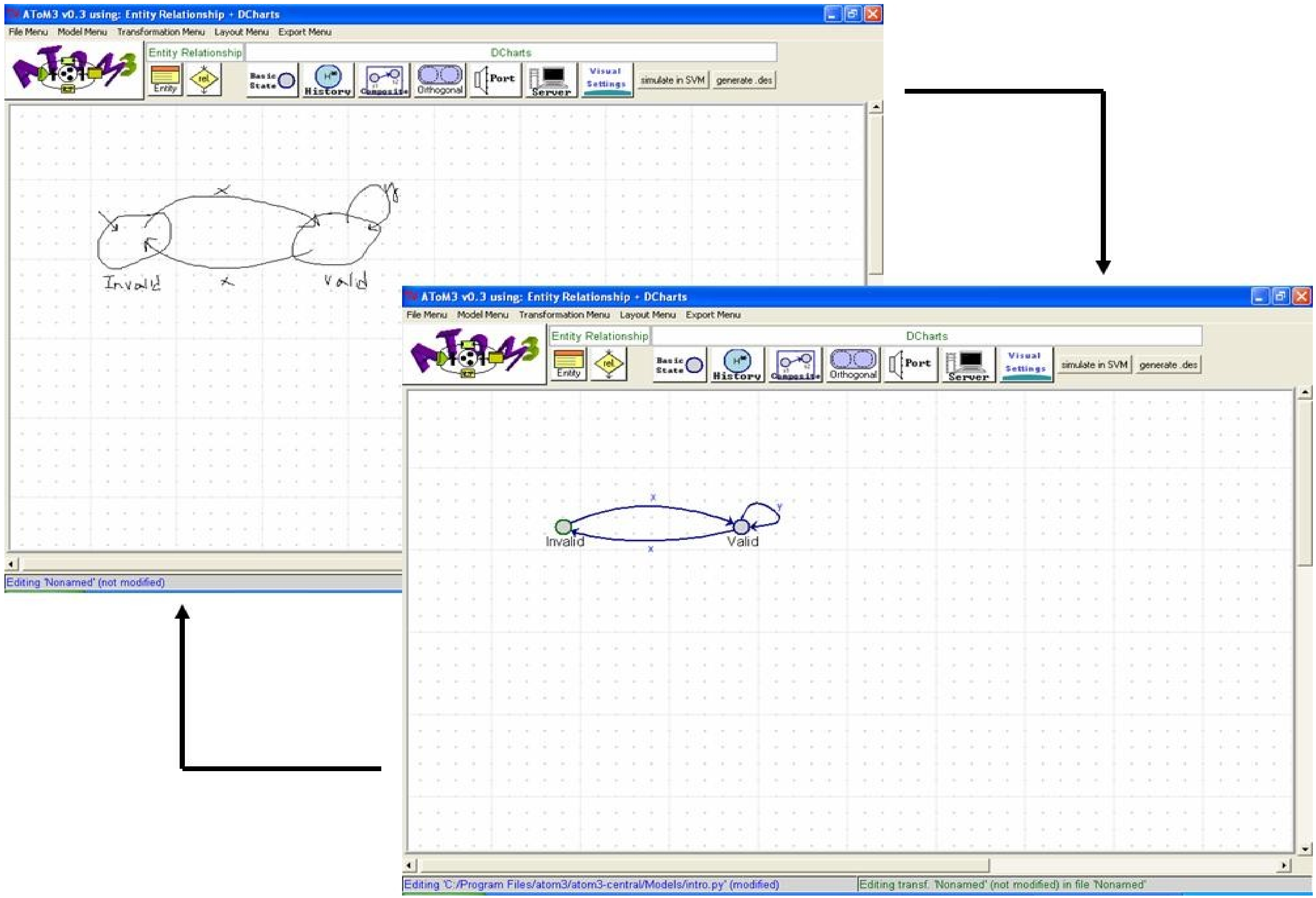
Syntax-directed Visual Editors: model behaviour

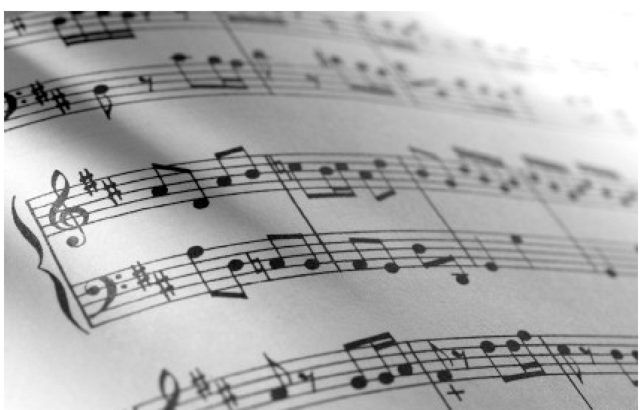
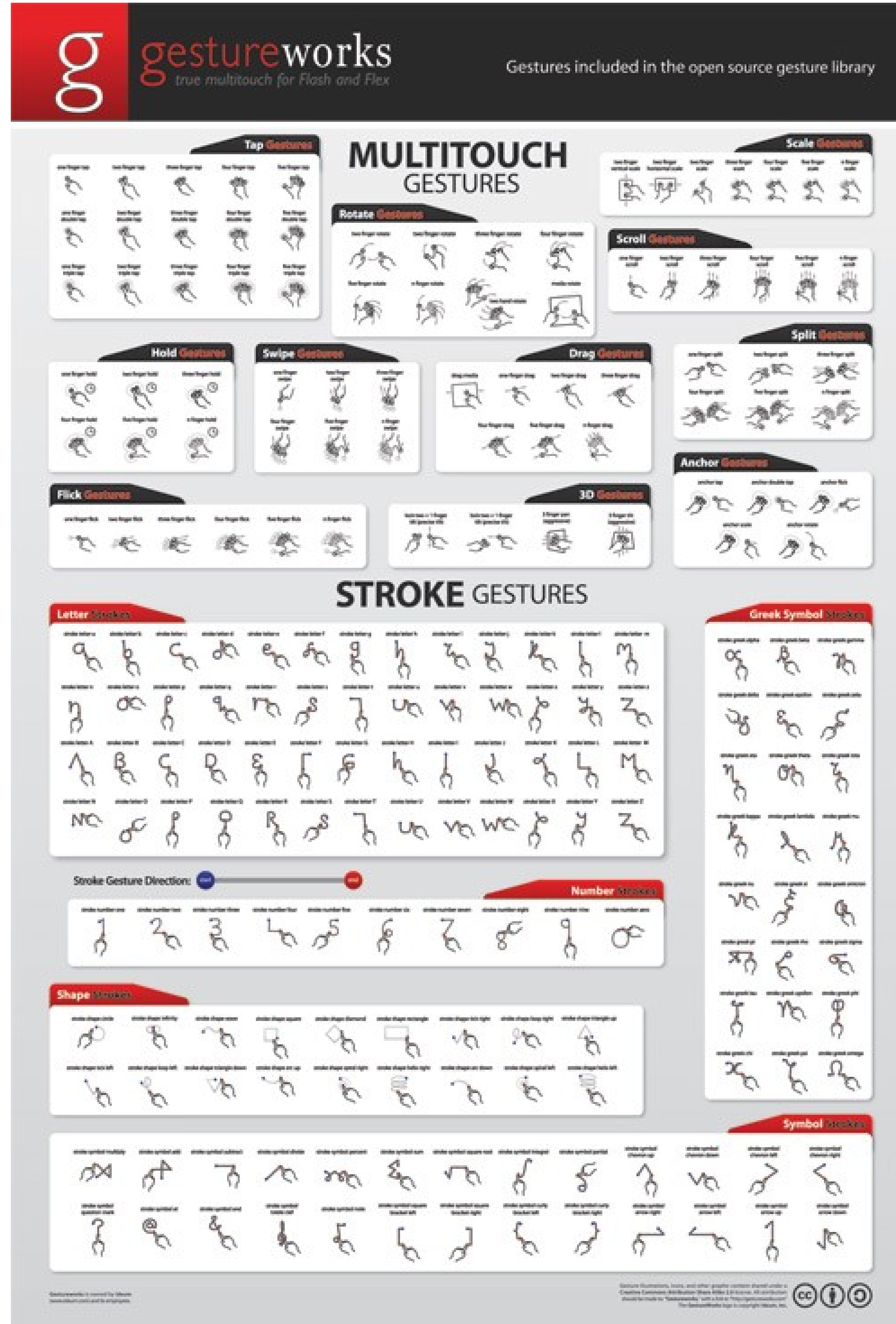


Generate Syntax-directed Visual Editors



Syntax-directed Visual Editors: freehand (early stages of multi-domain project)



Different Media:
Gestural Interaction, Sound, ...



IEEE TRANSACTIONS ON SOFTWARE ENGINEERING, VOL. 35, NO. 5, NOVEMBER-DECEMBER 2009

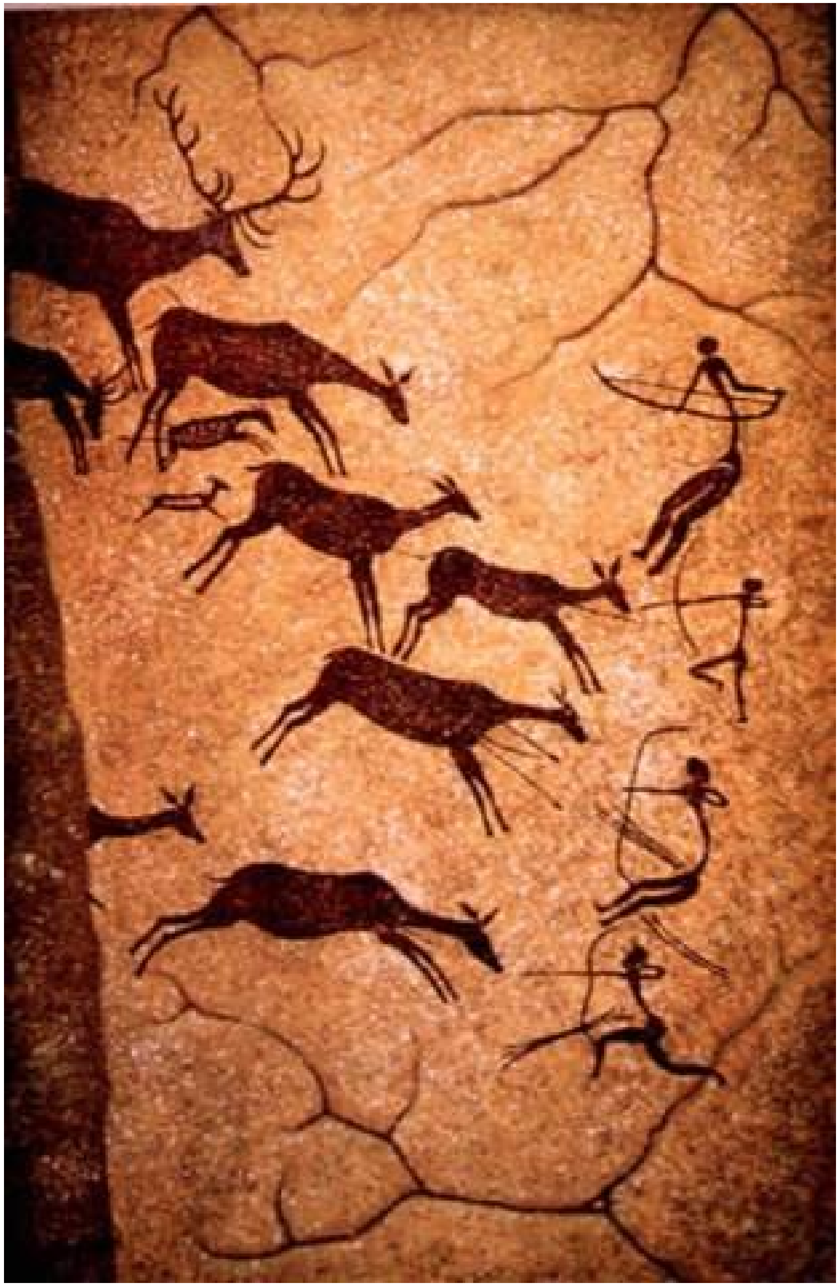
The "Physics" of Notations: Towards a Scientific Basis for Constructing Visual Notations in Software Engineering

Daniel L. Moody, *Member, IEEE*

Introduction

- Visual notations pre-date textual ones
- Visual notations are important for Modelling and Software Engineering
- Humans are excellent pattern recognizers
- Need cognitively efficient and effective notations.

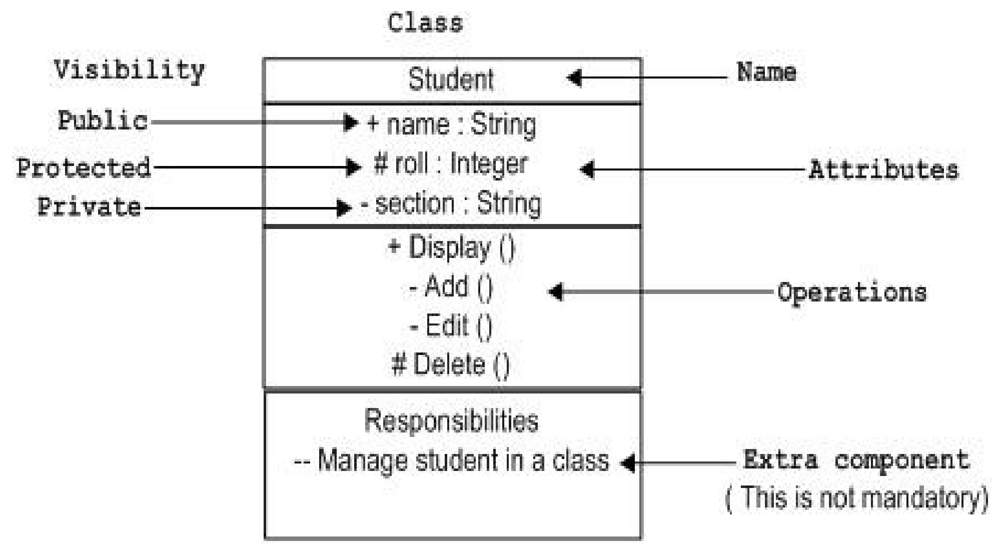
Cognitive effectiveness =
speed, ease and accuracy with which a representation can be processed by the human mind



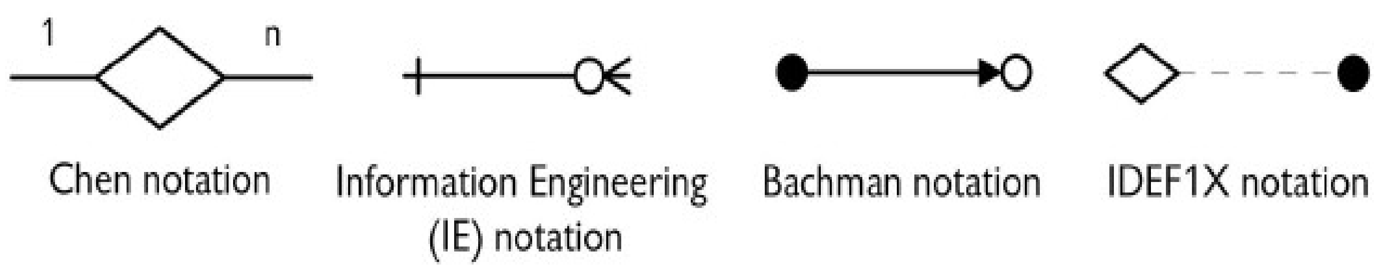
a DSVL @ Lascaux

Introduction/Rationale

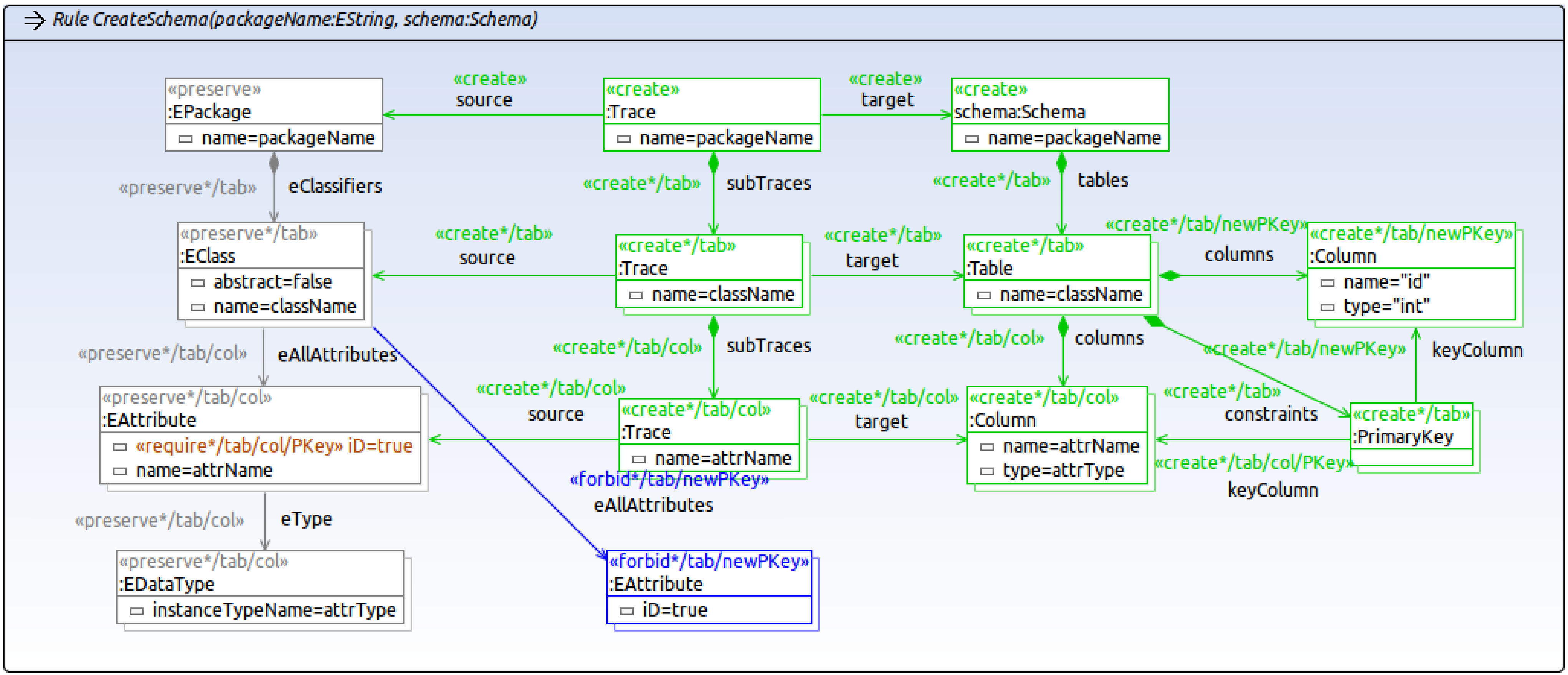
Visual notations are often introduced without underlying theory or rationale



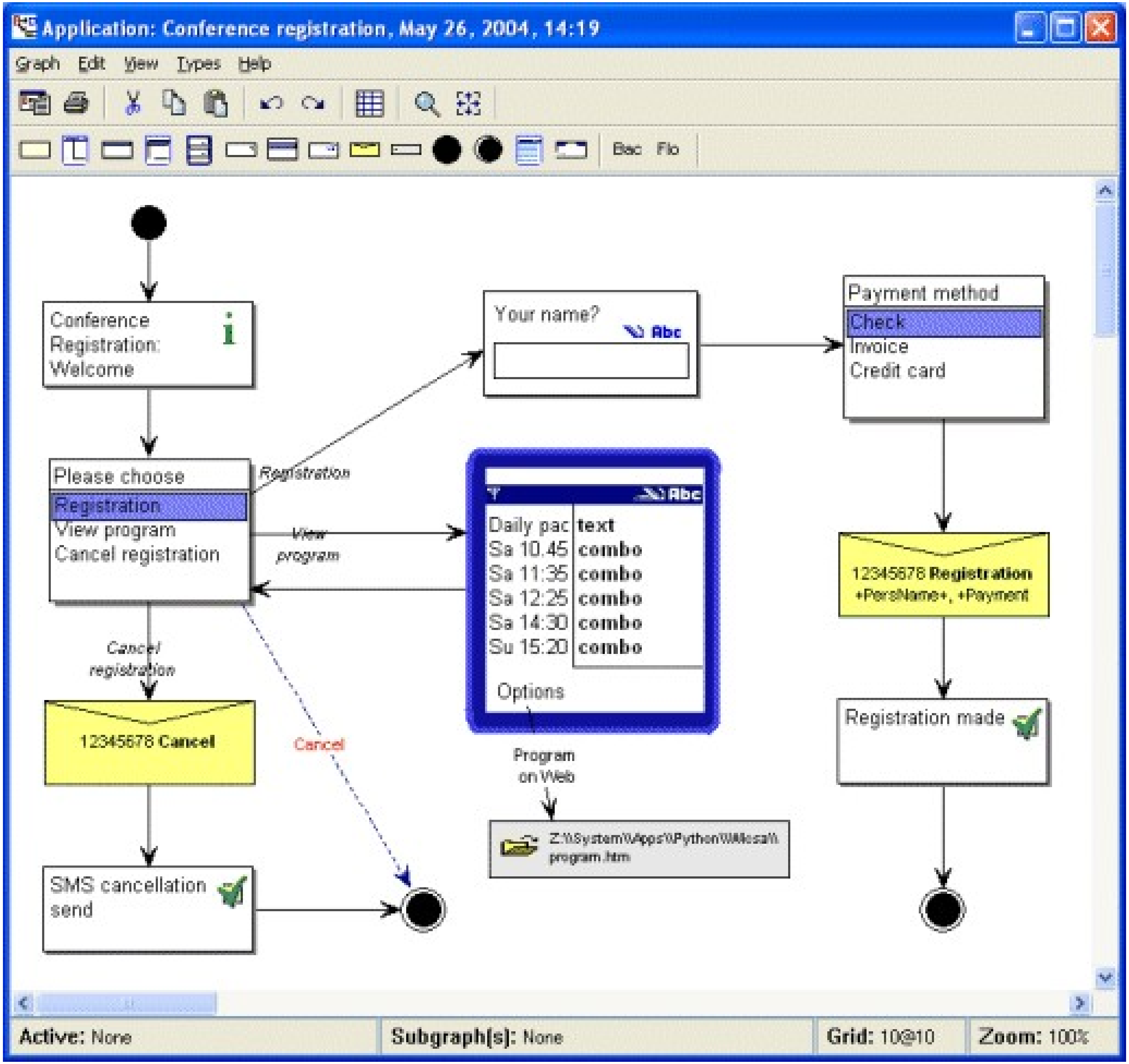
Many visual notations for same concepts.



No rigorous way to **compare** effectiveness and hence no clear design goal.



Rule CreateSchema(packageName:EString, schema:Schema)
«preserve»
:EPackage
name=packageName
«create»
source
«create»
:Trace
name=packageName
«create»
target
«create»
schema:Schema
name=packageName
«preserve*/tab»
eClassifiers
«create*/tab»
subTraces
«create*/tab»
tables
«preserve*/tab»
:EClass
abstract=false
name=className
«create*/tab»
source
«create*/tab»
:Trace
name=className
«create*/tab»
target
«create*/tab»
:Table
name=className
«create*/tab/newPKey»
columns
«create*/tab/newPKey»
:Column
name="id"
type="int"
«preserve*/tab/col»
eAllAttributes
«create*/tab/col»
subTraces
«create*/tab/col»
columns
«create*/tab/newPKey»
keyColumn
«preserve*/tab/col»
:EAttribute
«require*/tab/col/PKey» iD=true
name=attrName
«create*/tab/col»
source
«create*/tab/col»
:Trace
name=attrName
«create*/tab/col»
target
«create*/tab/col»
:Column
name=attrName
type=attrType
«create*/tab»
constraints
«create*/tab»
:PrimaryKey
«create*/tab/col/PKey»
keyColumn
«forbid*/tab/newPKey»
eAllAttributes
«preserve*/tab/col»
eType
«preserve*/tab/col»
:EDataType
instanceTypeName=attrType
«forbid*/tab/newPKey»
:EAttribute
iD=true


Application: Conference registration, May 26, 2004, 14:19
Graph Edit View Types Help
Bac Flo
Conference Registration: Welcome
Your name?
Abc
Payment method
Check
Invoice
Credit card
Please choose
Registration
View program
Cancel registration
Registration
View program
Abc
Daily pac
text
Sa 10.45
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Sa 11:35
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Sa 14:30
combo
Su 15:20
combo
Options
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+PersName+, +Payment
Cancel registration
12345678 Cancel
Cancel
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Z:\\System\\Apps\\Python\\Mosal\\ program.htm
SMS cancellation send
Active: None
Subgraph(s): None
Grid: 10@10
Zoom: 100%


Conference registration
Daily pa...
995,- USD
Sa 10.4...
T1: Smith
T2: Jackson
T3: Holland
Sa 11:3...
T4: Cohen
Sa 12:2...
T7: Dawson
Ok
Cancel
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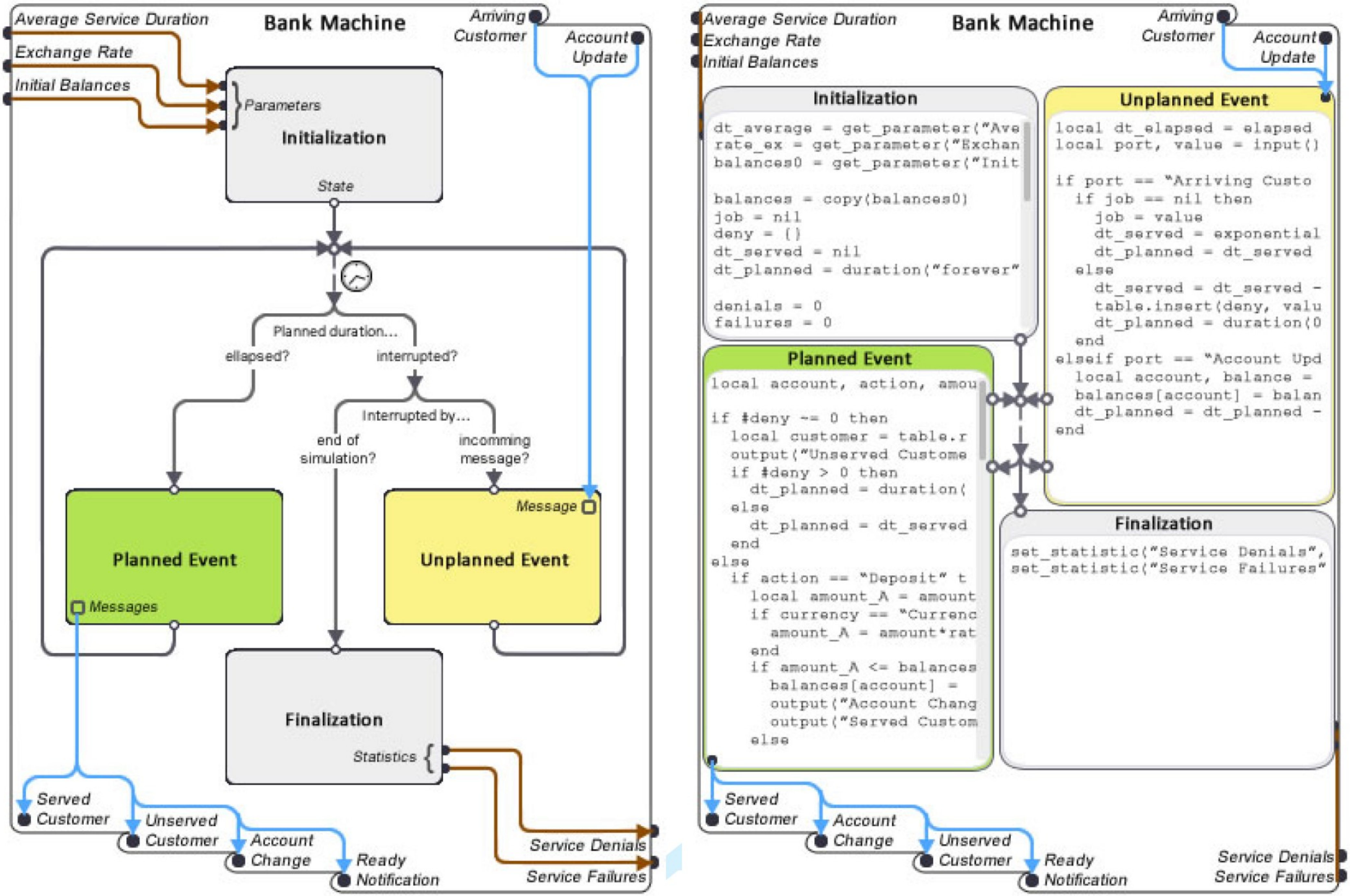
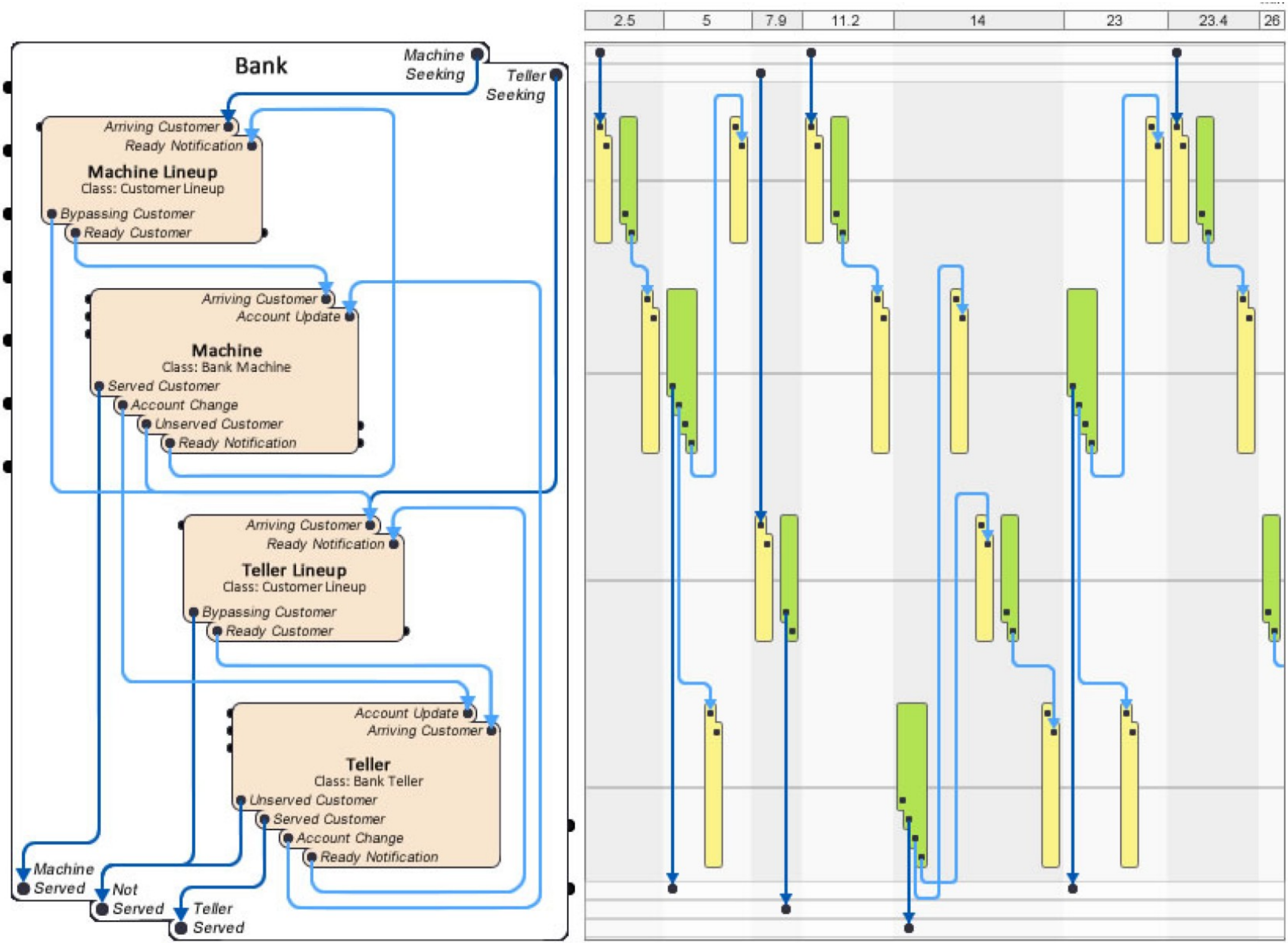
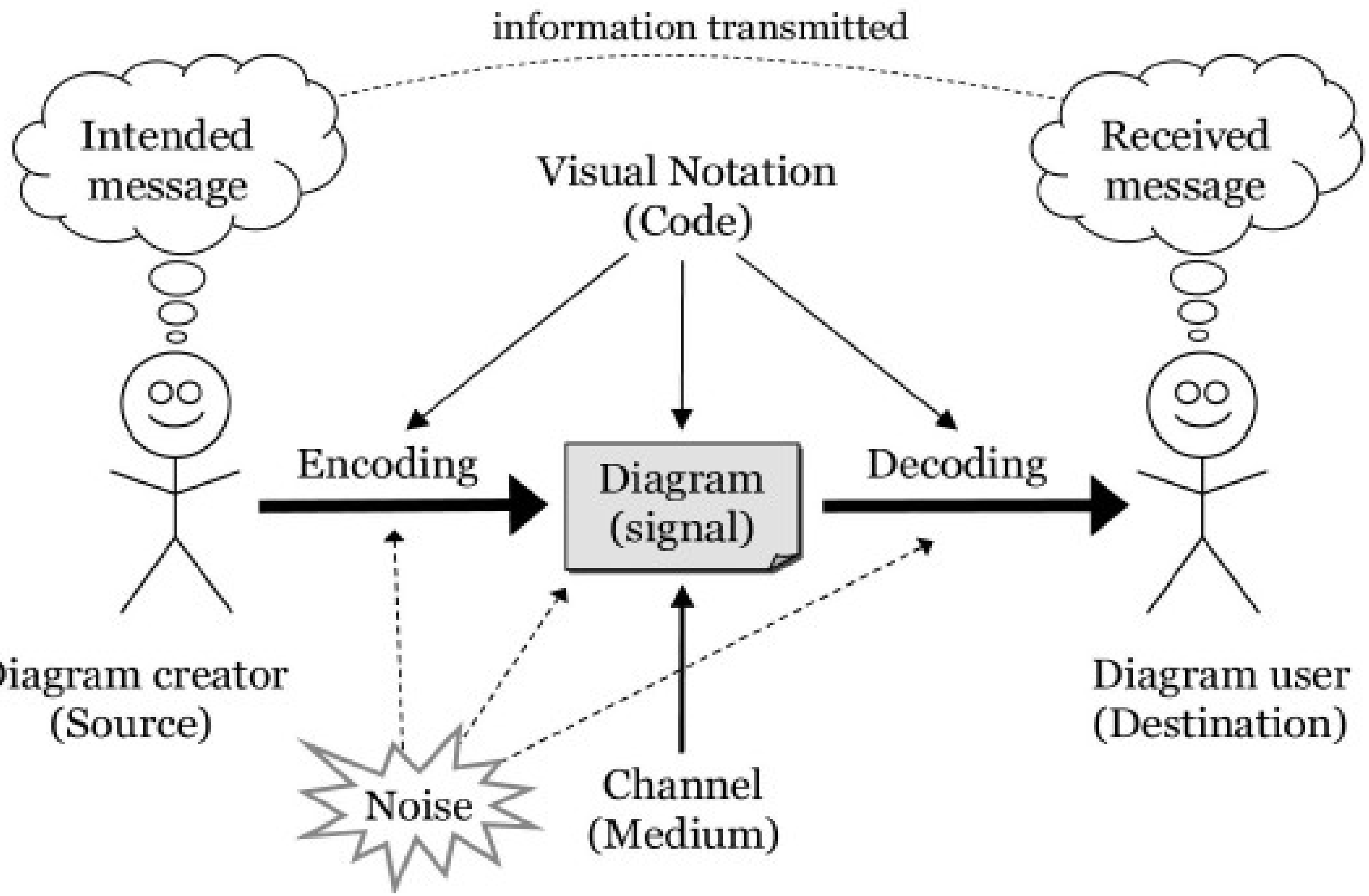


Maryam M. Maleki, Robert F. Woodbury, Rhys Goldstein, Simon Breslav, Azam Khan.
Designing DEVS visual interfaces for end-user programmers. Simulation 91(8): 715-734 (2015)

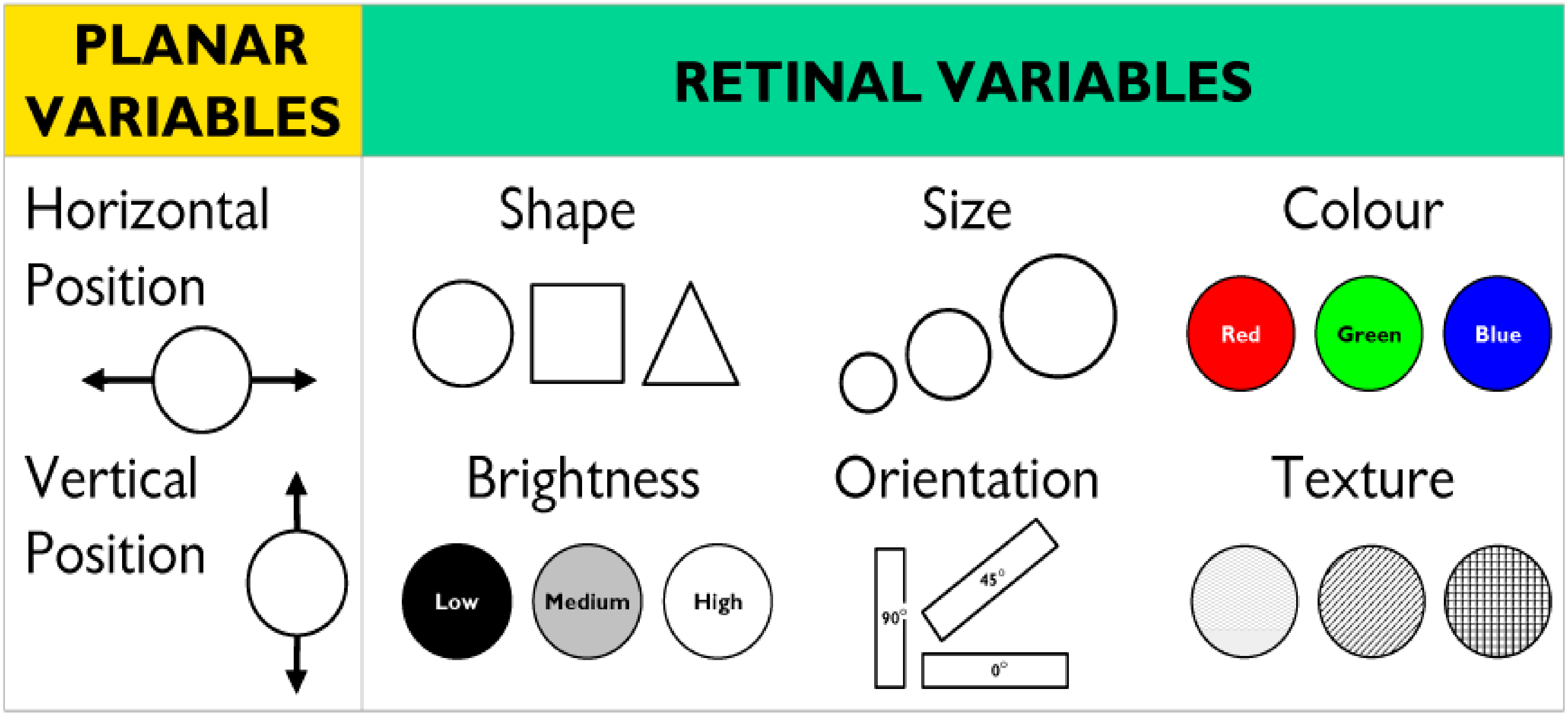


2.5
5
7.9
11.2
14
23
23.4
26
Bank
Machine Seeking
Teller Seeking
Arriving Customer
Ready Notification
Machine Lineup
Class: Customer Lineup
Bypassing Customer
Ready Customer
Arriving Customer
Account Update
Machine
Class: Bank Machine
Served Customer
Account Change
Unserved Customer
Ready Notification
Arriving Customer
Ready Notification
Teller Lineup
Class: Customer Lineup
Bypassing Customer
Ready Customer
Account Update
Arriving Customer
Teller
Class: Bank Teller
Unserved Customer
Served Customer
Account Change
Ready Notification
Machine Served
Not Served
Teller Served

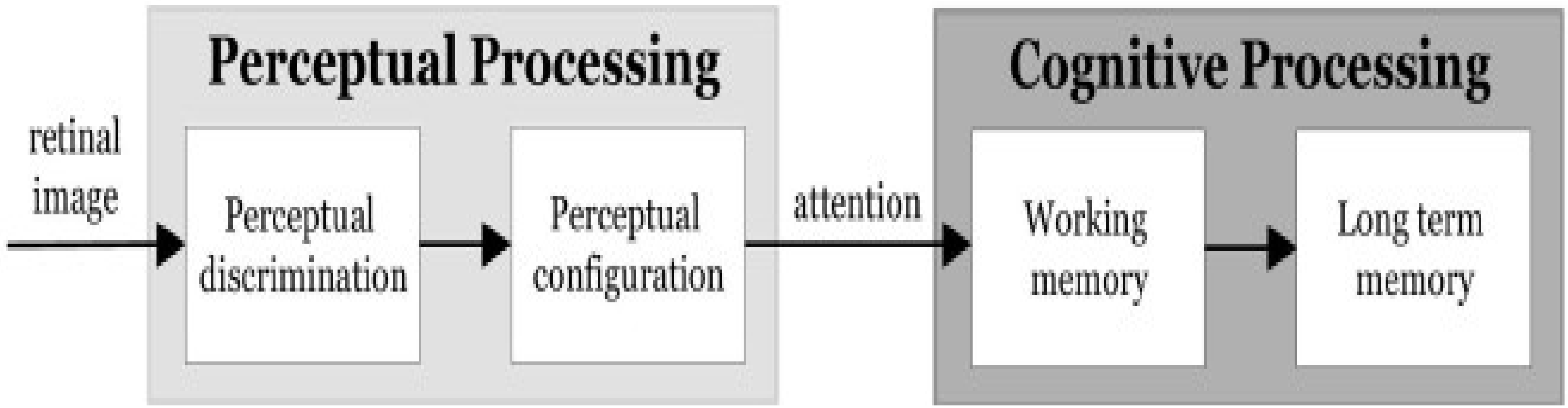
Communication Theory



Encoding: 8 visual variables to (graphically) encode information



Decoding



automatic, fast, parallel

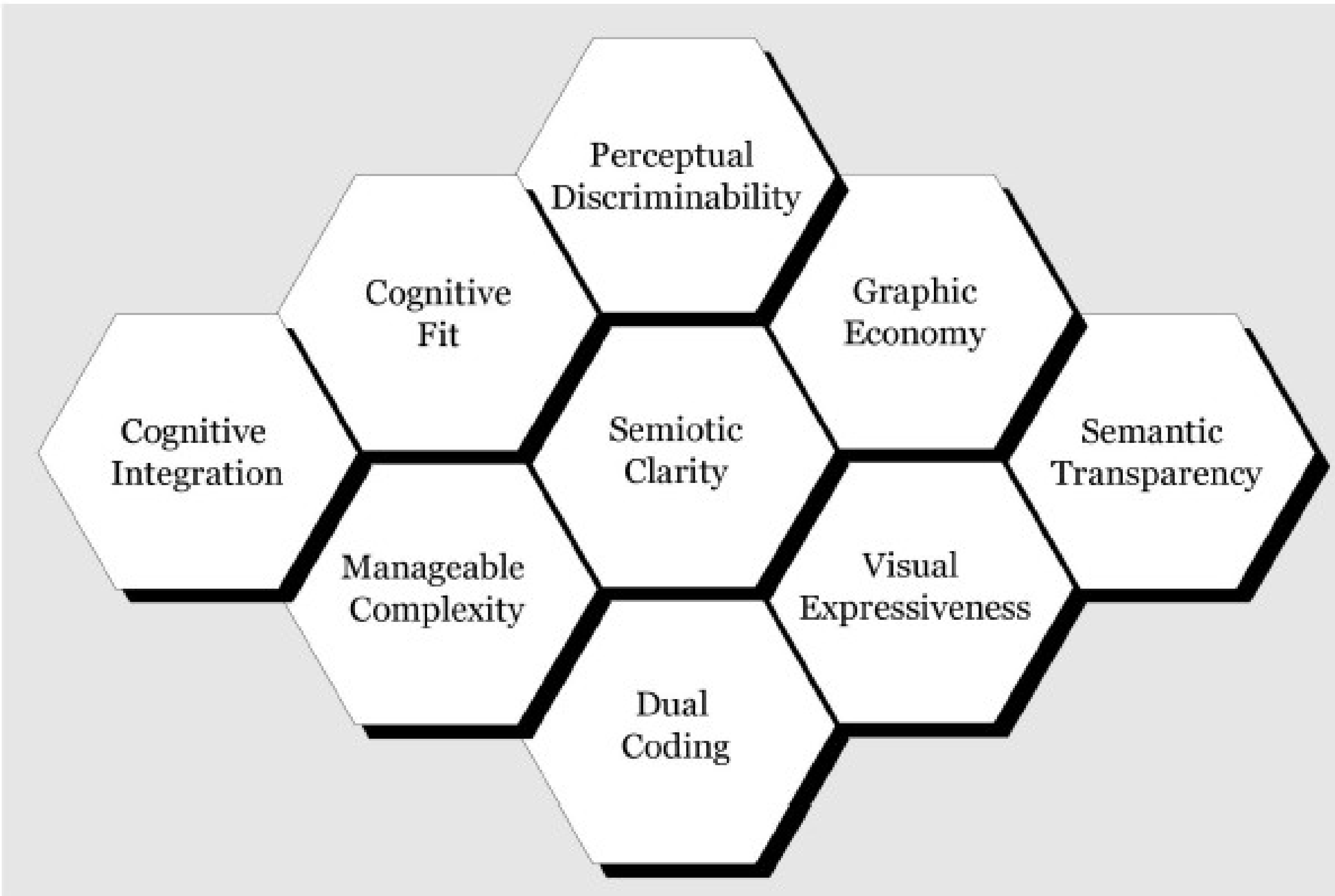
slow, large effort, sequential

Appropriate notations »
offload some of the burden from cognitive to perceptual

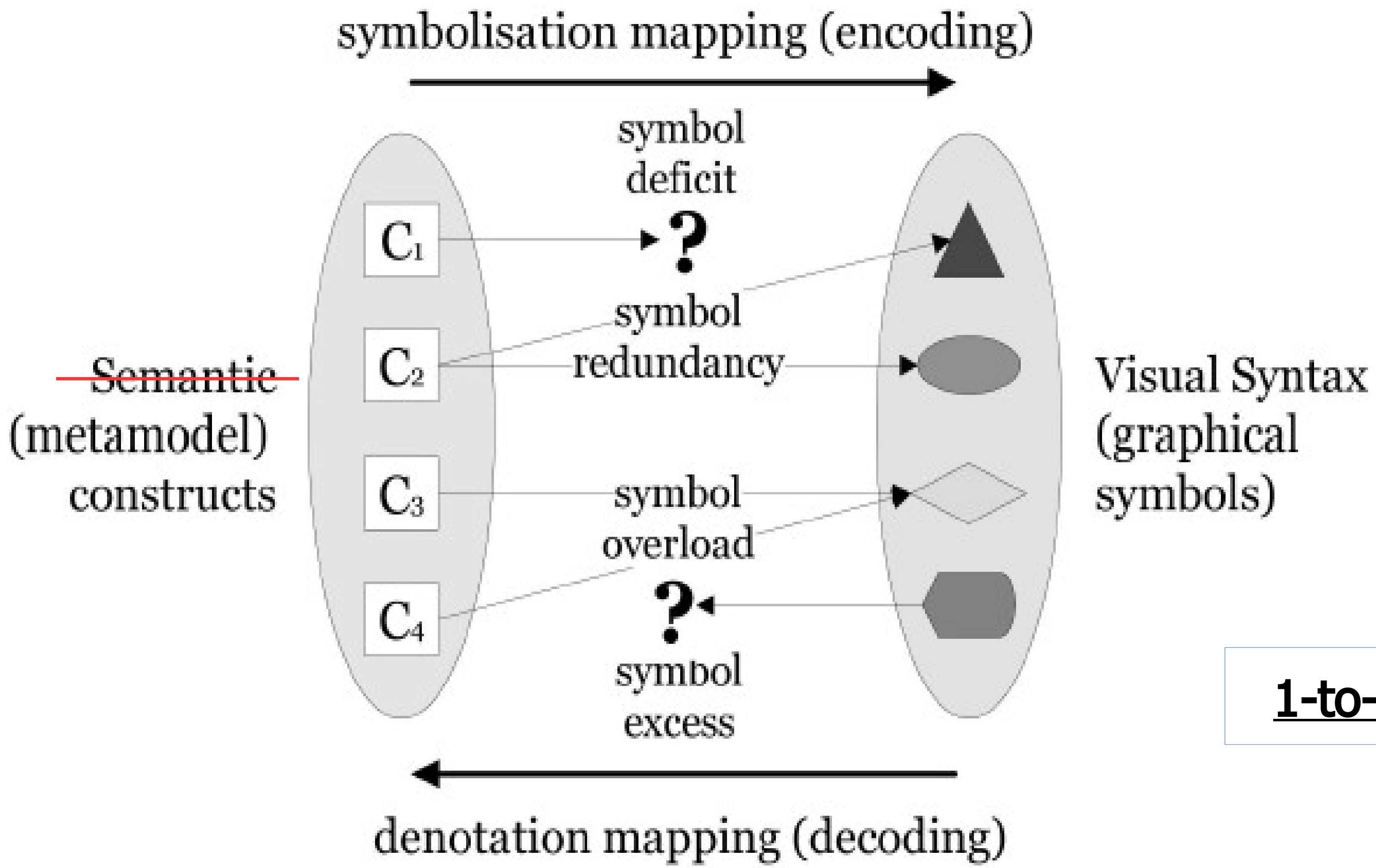
Note: "dual channel theory":
auditory/verbal channel and visual/pictorial channel are processed in parallel

Richard E. Mayer, Roxana Moreno. Nine Ways to Reduce Cognitive Load in Multimedia Learning. Educational Psychologist, 38(1), 43–5. 2003.

Principles for Designing Efficient and Effective Visual Notations

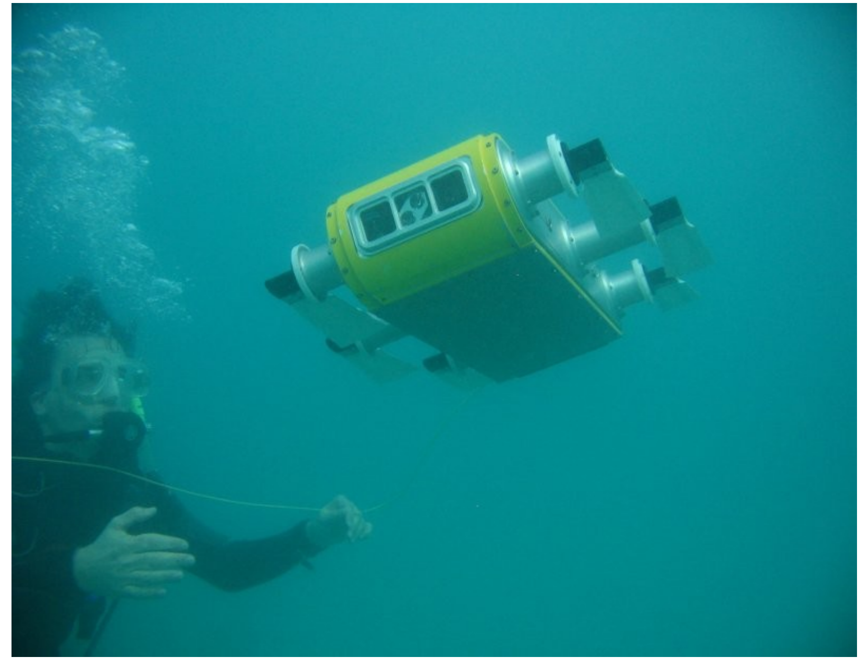


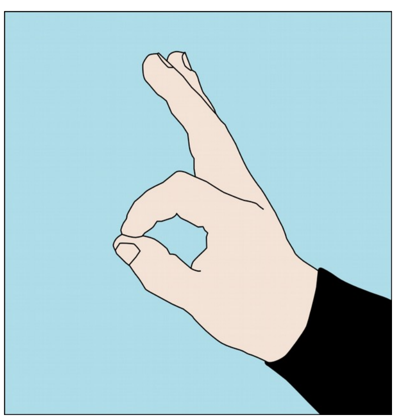
Semiotic Clarity (semiotics = study of signs and sign processes)

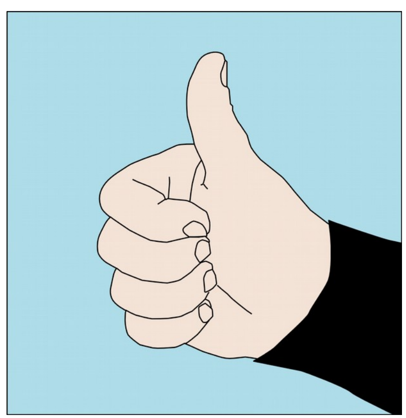


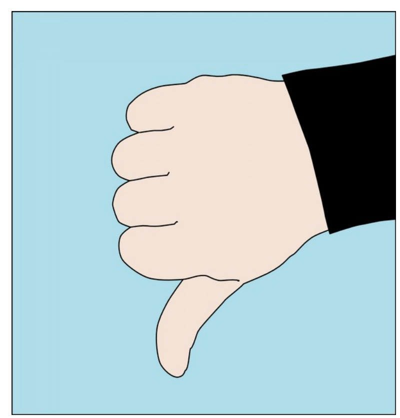
1-to-1

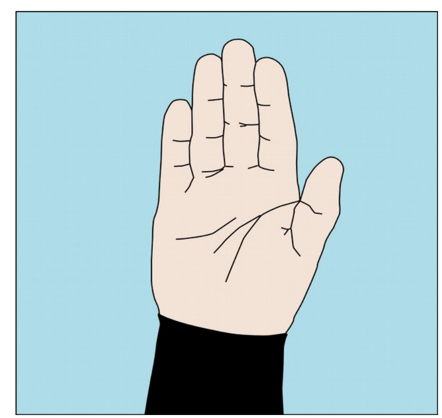
Perceptual Discriminability







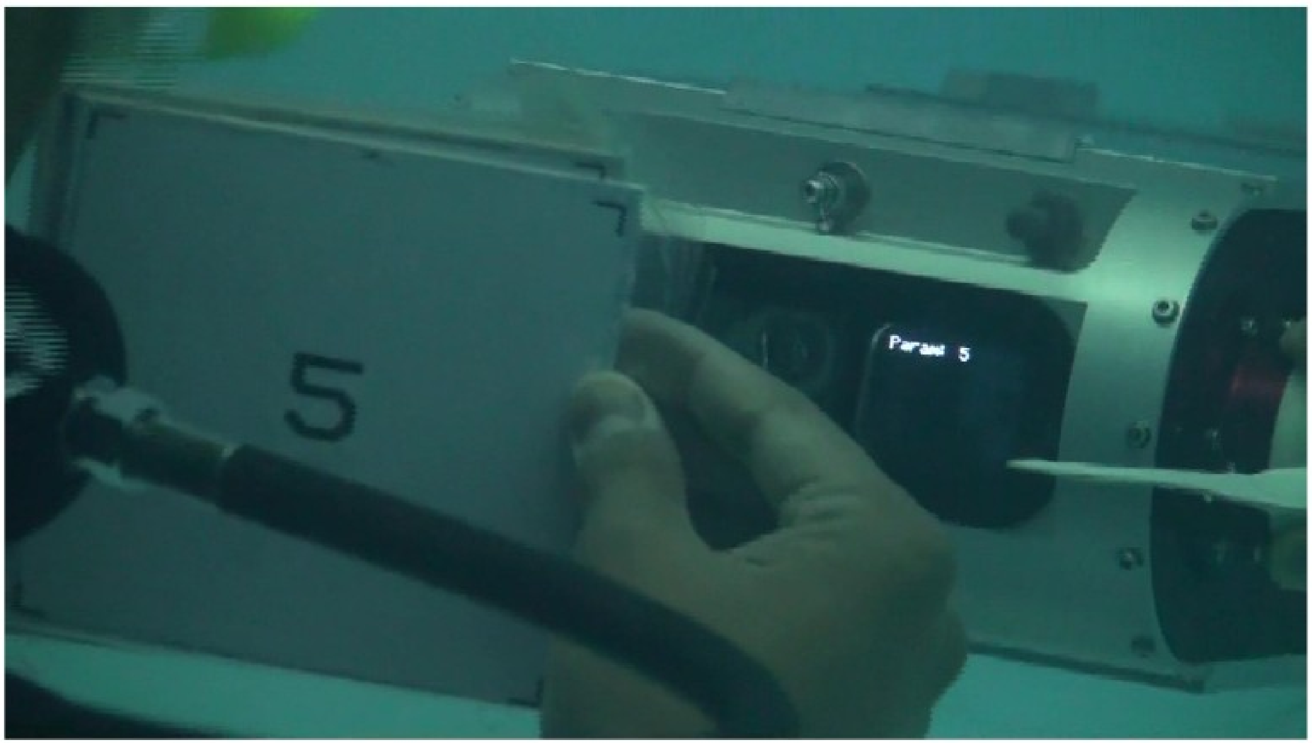




``Physics'' of Notations

(a) Divers programming Aqua2 during pool trials.

(b) A diver programming Aqua2 during an HRI trial held at a lake in central Québec.



(c) Example of command acknowledgement given on the LED screen of the Aqua2 robot during field trials.

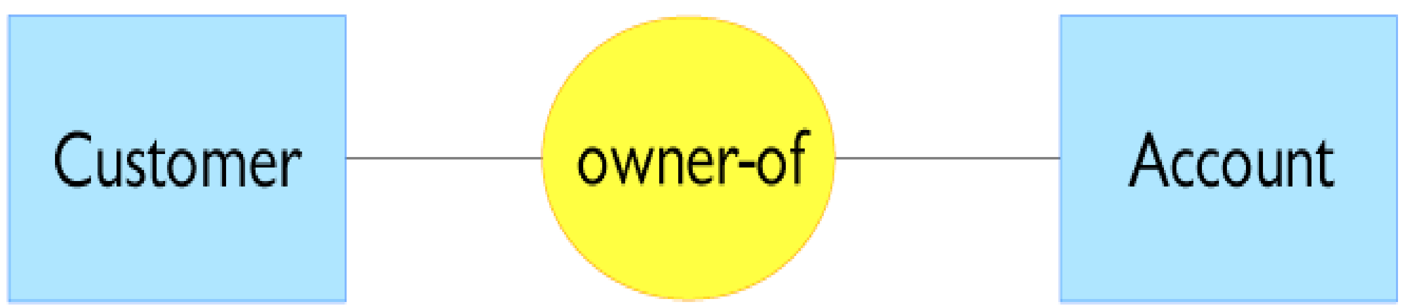
Junaed Sattar, Gregory Dudek. Reducing Uncertainty in Human-Robot Interaction: A Cost Analysis Approach. ISER 2010: 81-95.

Perceptual Discriminability

should be easy to **distinguish** visual symbols

ability to distinguish is determined by **visual distance**
larger visual distance » faster, more accurate recognition

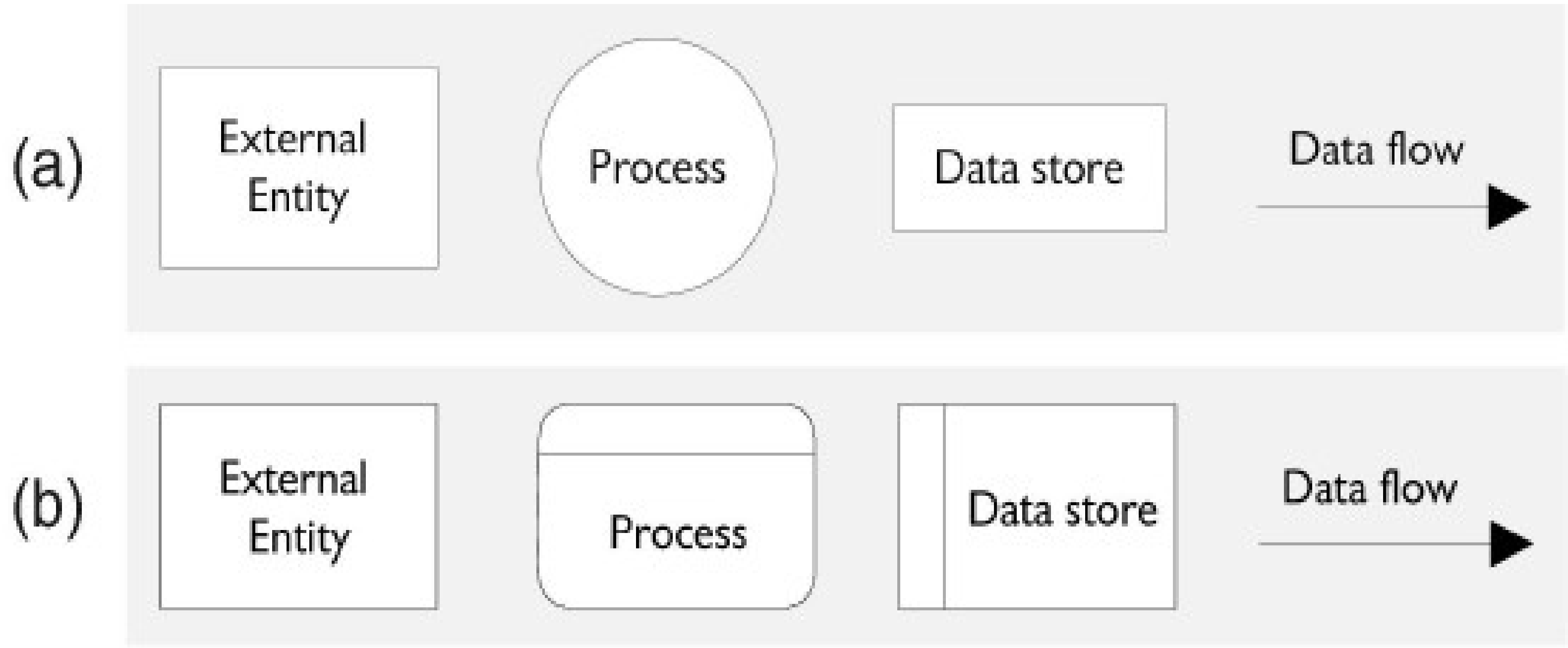
- **number** of visual variables on which they differ and the **magnitude** of the differences
- **shape** is the main visual variable



Perceptual Discriminability

Software Engineering notations mostly use rectangle variants

Use **redundant** visual encoding to **increase distance** (e.g., textual + visual)



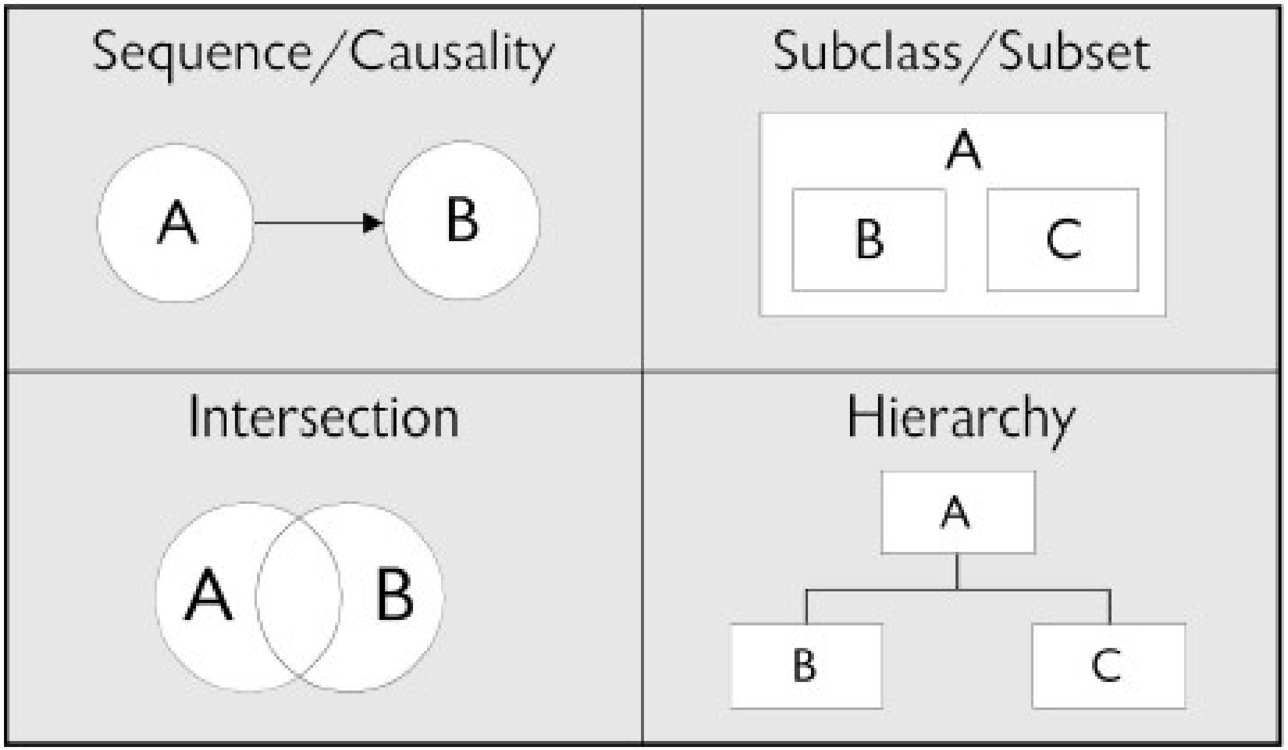
Semantic Transparency

The **meaning** of a symbol can be **inferred** from its **appearance** (intuitive)

Symbols can be:

Semantic Transparency: semantically immediate symbols

Semantic Transparency

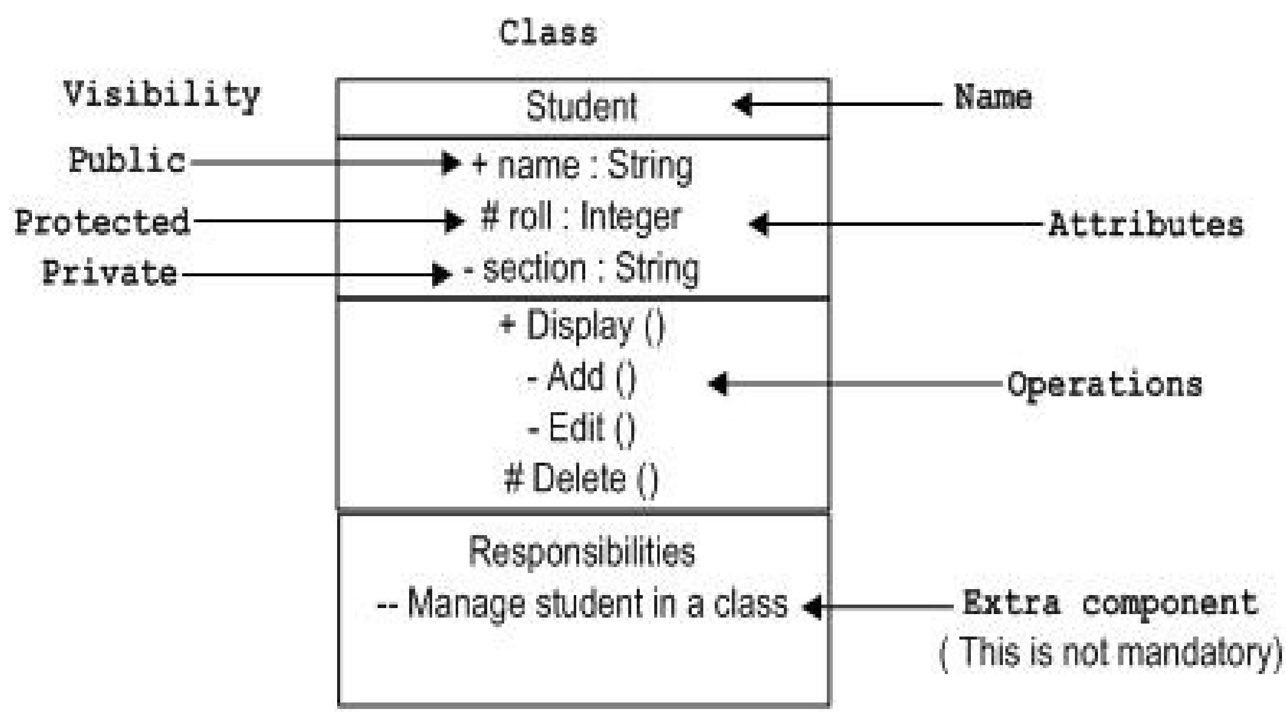


Semantic Transparency

The **meaning** of a symbol can be **inferred** from its **appearance** (intuitive)

Symbols can be:

- Semantically Immediate
- Semantically Opaque



Software Engineering notations are usually abstract (non-intuitive)

Semantic Transparency: semantically perverse symbols

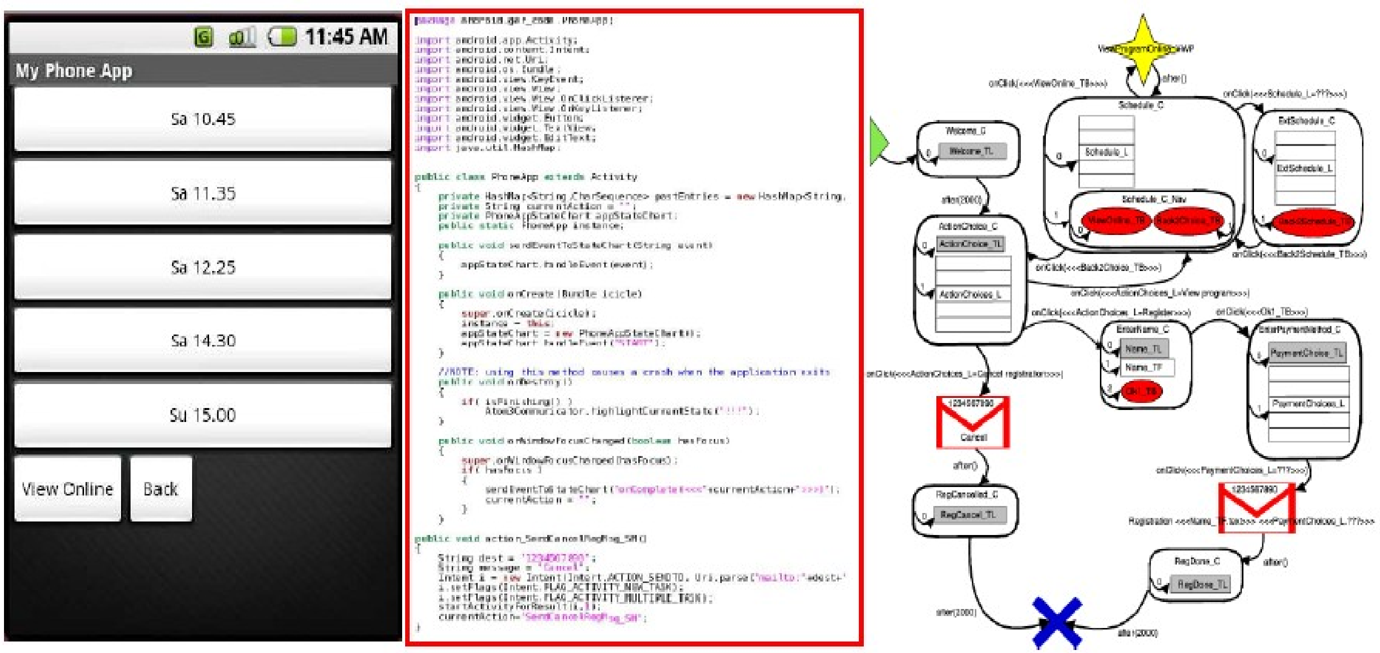
Semantic Transparency

The **meaning** of a symbol can be **inferred** from its **appearance** (intuitive)

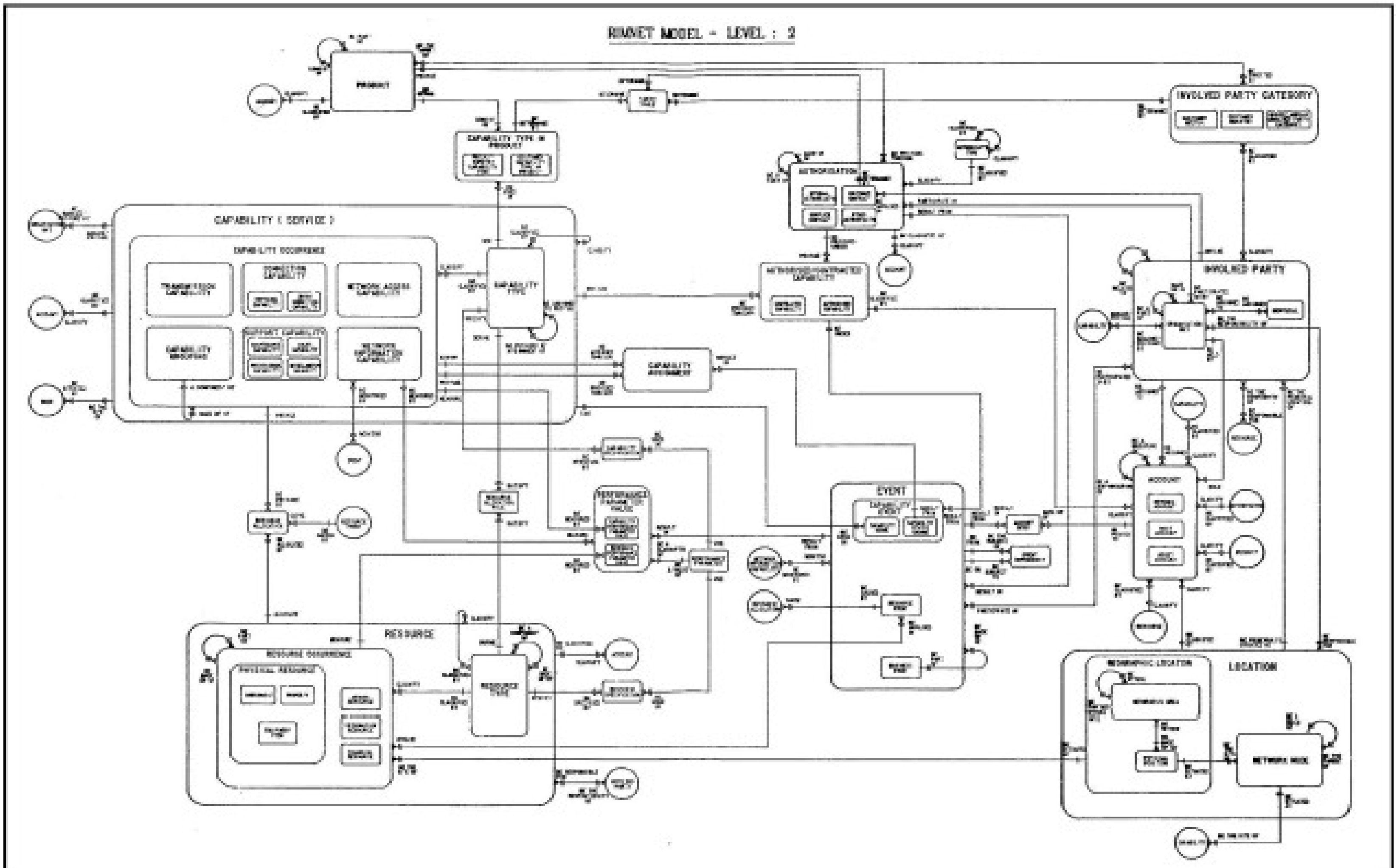
Symbols can be:

- Semantically Immediate
- Semantically Opaque
- Semantically Perverse

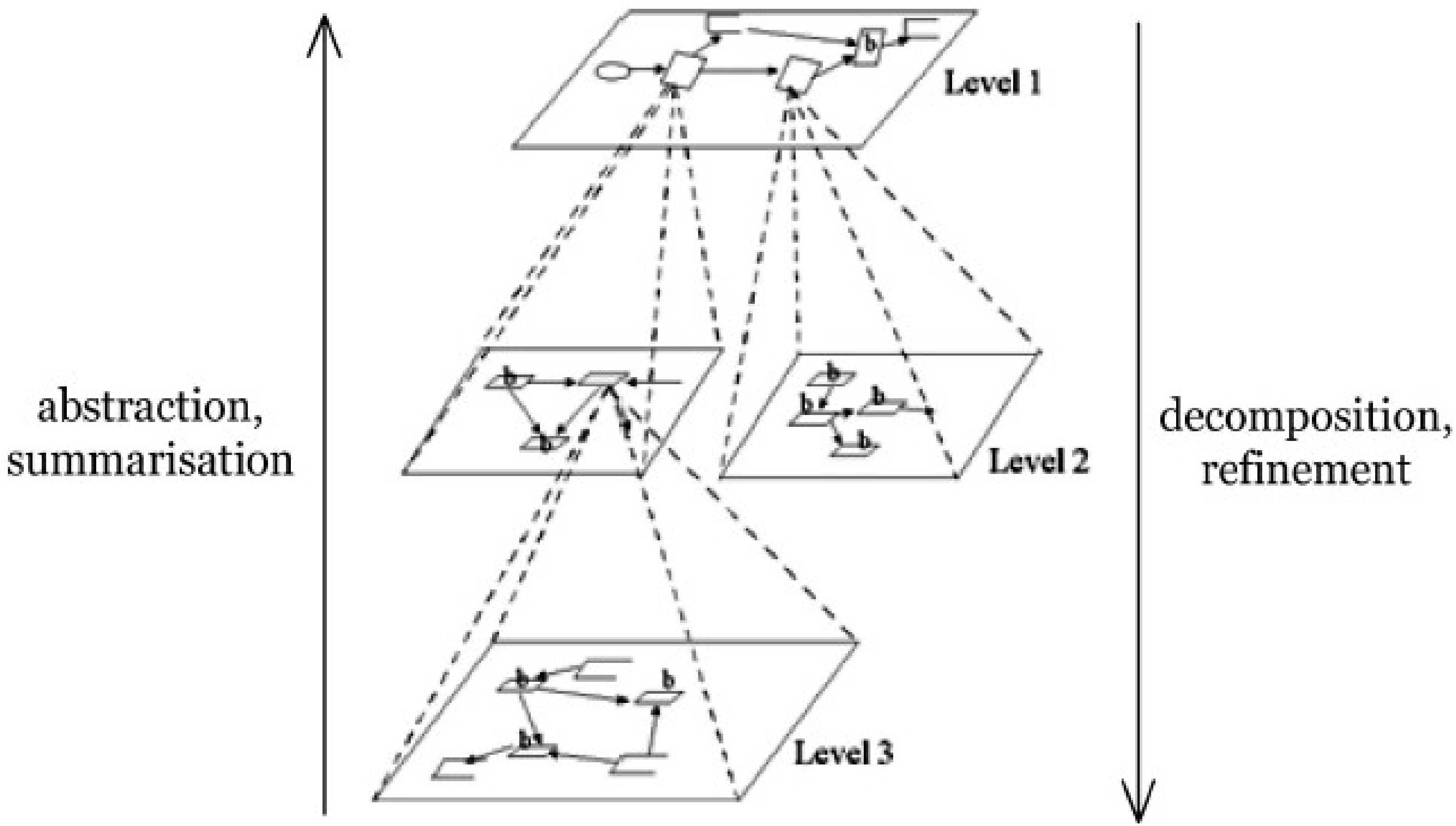
Domain-specific icons and visual arrangement should be intuitive



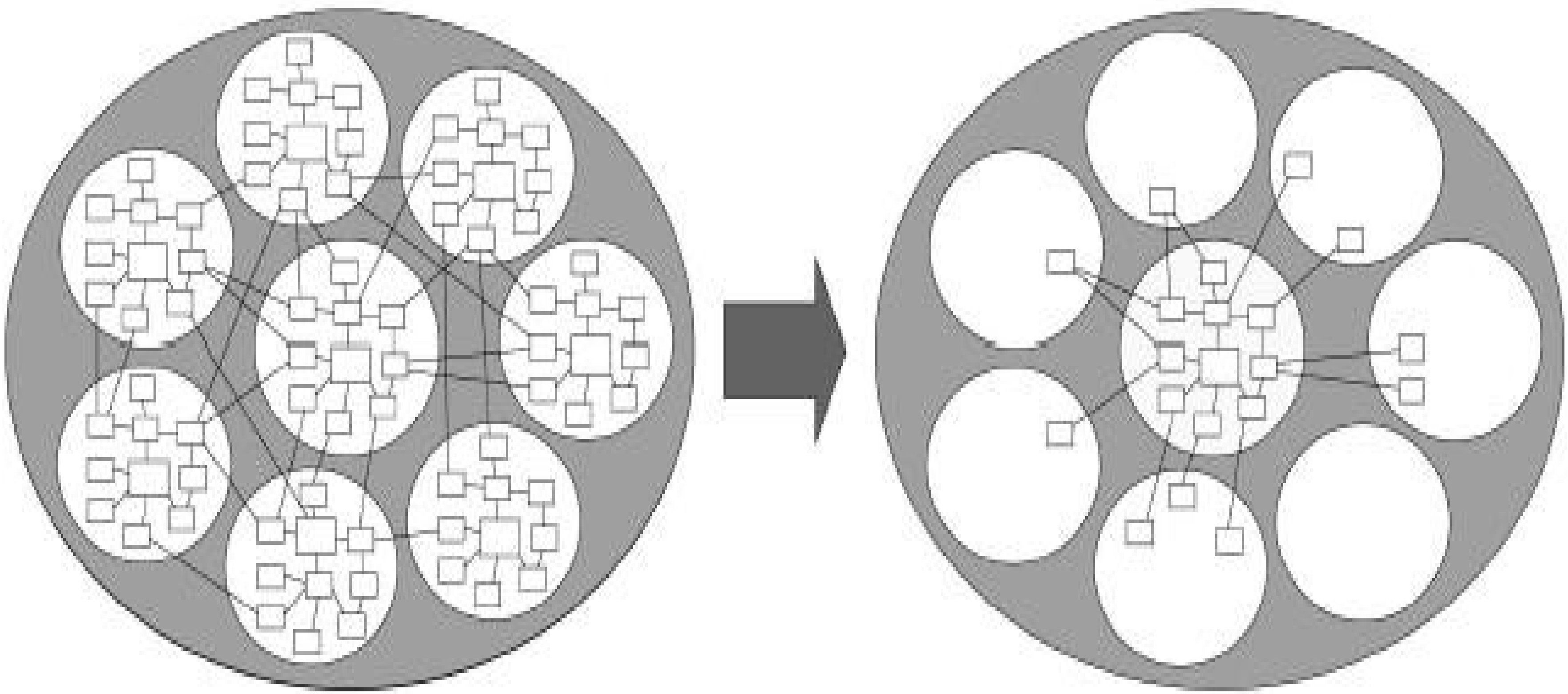
Complexity management (# elements in diagram » cognitive overload)



Modularization/Hierarchy



Cognitive Integration (different notations)

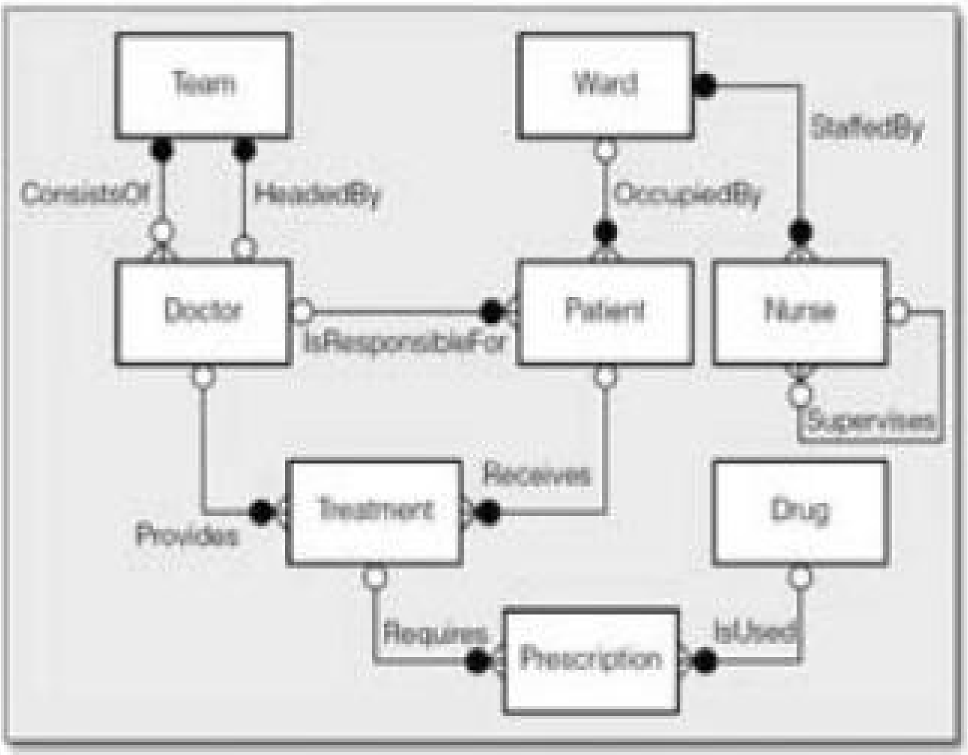


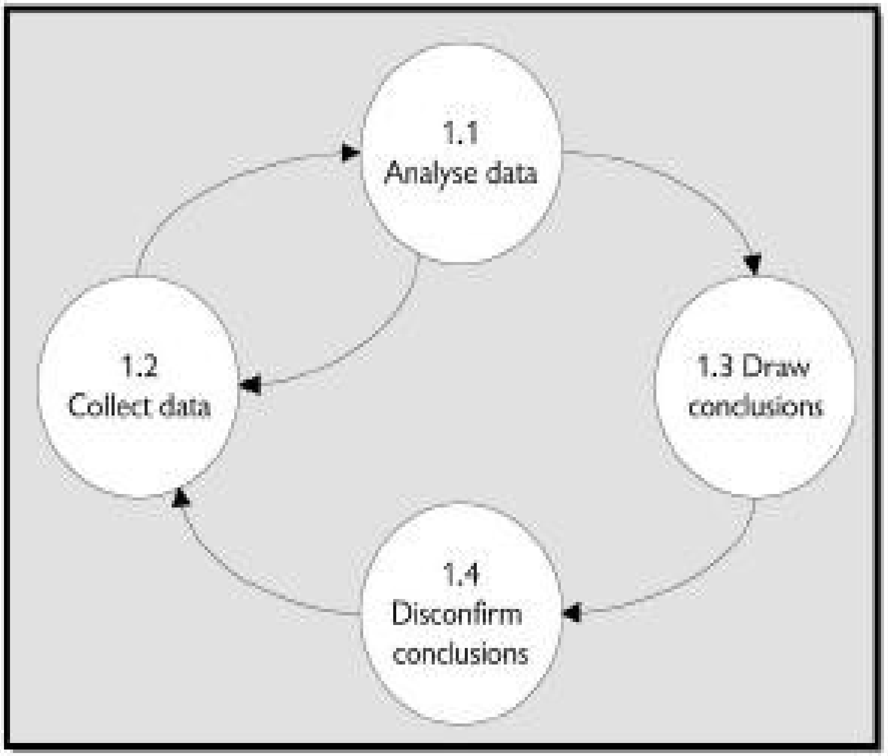
- Conceptual integration (**coherent** mental model)
- Enable **navigation** and **transition** between notations

Visual Expressiveness

Number of visual variables used (UML, mostly shape, no colour)

8 degrees of visual freedom (0 = non-visual – 8 = visually saturated)





Visual Expressiveness

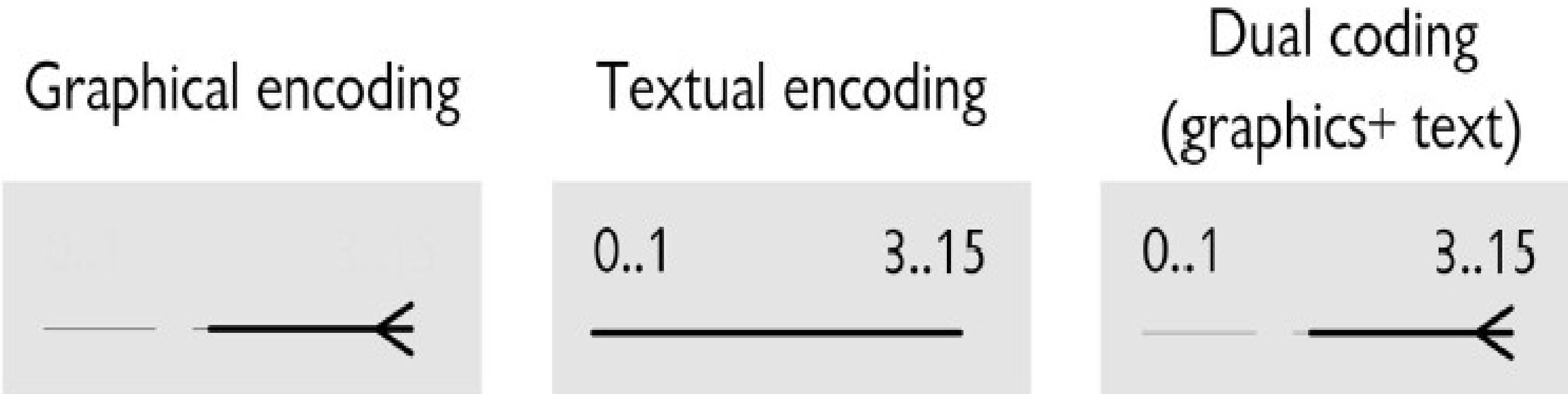
Different visual variables have **different capacity** to encode information

Variable	Power	Capacity
Horizontal position (x)	Interval	10-15
Vertical position (y)	Interval	10-15
Size	Interval	20
Brightness	Ordinal	6-7
Colour	Nominal	7-10
Texture	Nominal	2-5
Shape	Nominal	Unlimited
Orientation	Nominal	4

Dual Encoding

Combine **Textual** and **Visual**

Supplement rather than duplicate (e.g., multiplicity values)

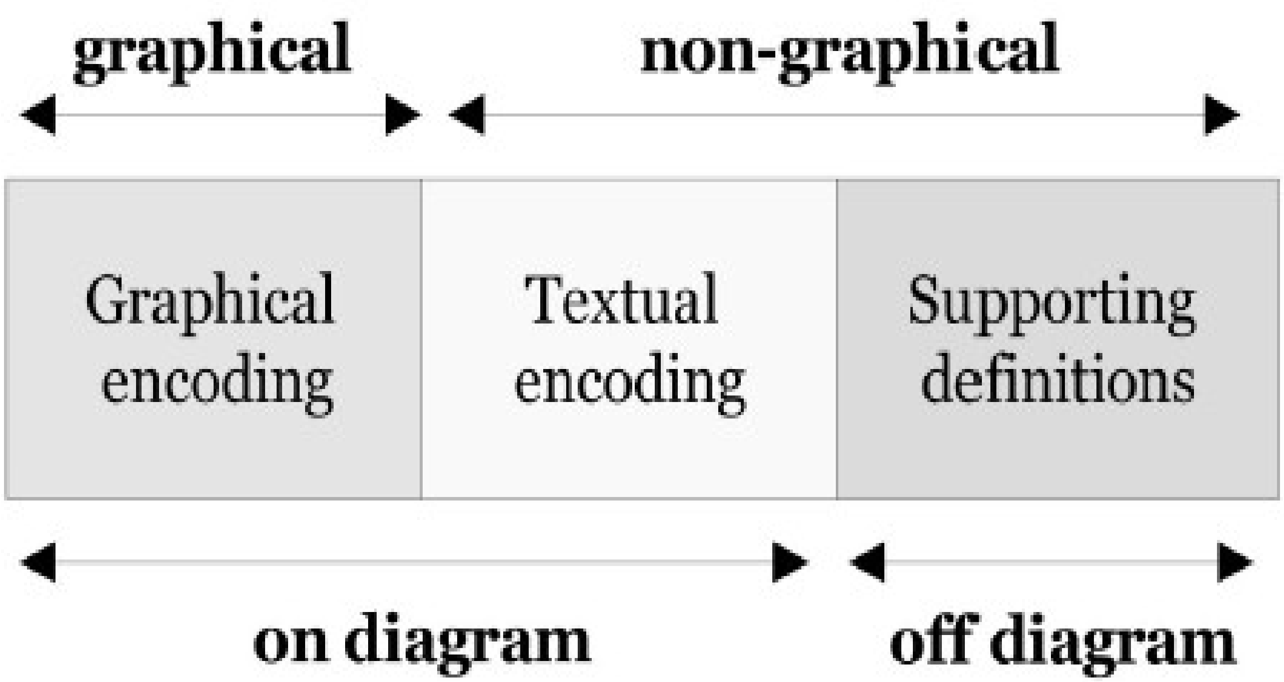


Reinforce meaning

Graphic Economy

- Not too many symbols. If many, provide **legend**
- Limit on human discrimination capability (6 levels per variable)
- Upper limit on graphic complexity

How?



Cognitive Fit

Adapt choice of visual notation to

- Task
- Audience (novices vs. experts)

Adaptation may be dynamic (“learn” about Task/User proficiency)

Representation medium matters

Interactions among principles

	Semiotic Clarity	Perceptual Discriminability	Semantic Transparency	Complexity Management	Cognitive Integration	Visual Expressiveness	Dual Coding	Graphic Economy	Cognitive Fit
Semiotic Clarity								±	
Perceptual Discriminability						+			+
Semantic Transparency		+							±
Complexity Management								−	+
Cognitive Integration	−			+				−	
Visual Expressiveness		+						+	±
Dual Coding									+
Graphic Economy		+		+		−			+
Cognitive Fit